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FARMERS' BULLETINS

Nos. 1626-1650

WITH CONTENTS

PREPARED IN THE INDEXING SECTION



UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1931

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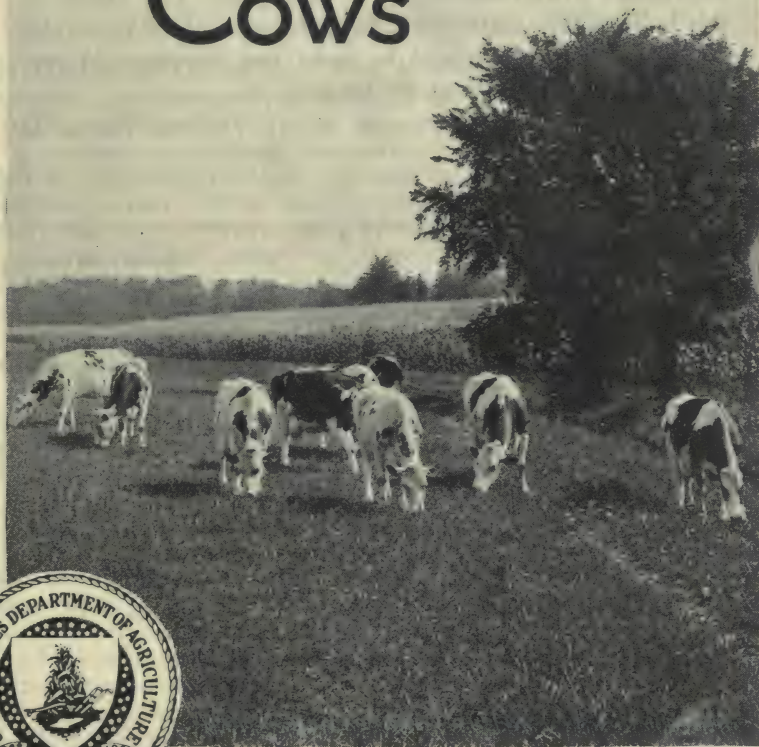


U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1626

Rev Nov 1940

Feeding Dairy Cows



U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF PLANT INDUSTRY

THE FEED of the dairy cow constitutes about one-half the expense of milk production. Profitable milk production, therefore, demands close attention to the matter of feed. The ration must be adequate in quantity, suitable in quality, but as low in cost as possible. The quantities of feed to be given the cow for most economical production have been determined with a fair degree of accuracy. The object of this bulletin is to state in simple terms some of the principles of dairy-cow nutrition and to assist the dairyman in preparing economical rations for his cows.

This bulletin supersedes Farmers' Bulletin 743, The Feeding of Dairy Cows.

Washington, D. C.

Issued April 1930
Revised May, 1936

FEEDING DAIRY COWS

By T. E. WOODWARD, *senior dairy husbandman, Division of Dairy Cattle Breeding, Feeding, and Management*, and A. B. NYSTROM, *senior dairy husbandman, Administrative Division, Bureau of Dairy Industry*

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HOW A DAIRY COW USES HER FEED

THE RATION of a dairy cow is used for five main purposes, namely, maintenance, growth, body fat, development of fetus, and milk production.

A maintenance ration is an amount of feed equivalent to that needed to keep the cow at constant weight when not giving milk or carrying a calf. It is used to keep the vital organs functioning properly, to replace worn body tissue, to maintain body temperature, and to provide energy for muscular activity, such as standing or moving about. The maintenance ration must be considered somewhat as a necessary overhead expense. The quantity required varies in general with the weight of the animal.

An immature animal uses a portion of its feed for growth. For this reason it needs a larger ration than a mature animal of the same weight. The ration for growth requires somewhat more protein than does the maintenance ration.

The feed needed for body fat is of no considerable consequence except during the time when the cow is dry or nearly so; at this time she is storing up a reserve to use after calving.

When the cow is carrying a calf she needs extra feed to provide for the development of the fetus and the membranes and fluids co-existent with pregnancy. The quantity of feed required for these purposes is not large but is sufficient to be considered.

The feed required for the production of milk depends on the quantity and composition of the milk. The greater the quantity and the richer the milk, the greater the quantity of nutrients needed in the feed. When a cow is underfed she diverts some of the nutrients from maintenance to milk. She loses flesh, and the yield of milk also declines.

IMPORTANCE OF THE VARIOUS FEED CONSTITUENTS

PROTEINS

Proteins in the feed are used to make the proteins of milk, blood, lean meat, and all nitrogenous body tissues. They are used in the repair of parts broken down in the ordinary course of bodily activities. For the purposes enumerated no other constituent can take their place. In addition to these uses proteins can also be employed in making fat and providing energy.

Proteins are made up of various amino acids. If a cow is to produce all the milk of which she is capable by inheritance she must receive a sufficient amount of each of the various amino acids used for maintenance and milk production. Since different proteins contain different proportions of the amino acids, the cow needs not only an ample quantity of protein but also various kinds of this constituent. This will usually call for the feeding of materials derived from several species of plants. When the constitution of the proteins and the characteristics of the amino acids become better known it may be possible to reduce both the quantity of proteins and the number of the sources from which they are obtained. All feeding standards specify an amount of digestible protein somewhat in excess of that found in milk. A moderate excess is not known to be detrimental to the health of the animal. Furthermore, since the proteins not used for milk production can be used to make fat or energy, they are not necessarily wasted. The fact that in most dairy sections of the United States feeds high in protein are more expensive than those low in this constituent is probably the main reason for using a ration containing the smallest quantity needed for continuous high production.

CARBOHYDRATES

The principal substances in feeds making up carbohydrates are starches, sugars, and crude fiber. These are used to maintain body heat, to make body fat and milk fat, and to provide energy for every muscular activity, such as mastication, respiration, and locomotion. Crude fiber is the least digestible of these substances. Feeds containing more than 18 percent of fiber in the dry substance may be classed as roughages, and those containing less as concentrates. Carbohydrates are more plentiful than proteins and are usually cheaper. This is one reason why it is generally unwise to use proteins for any purpose that carbohydrates will serve.

FATS

Fats in feeds are used for the same general purposes as carbohydrates, but on the basis of equal weights of each they are about two and one-fourth times as efficient as carbohydrates. They also lubricate the digestive tract and aid in making a glossy coat. Since most rations probably contain fats in sufficient quantities for satisfactory nutrition, no special consideration need be given the fat content in the preparation of the ration.

MINERALS

Minerals comprise a variety of compounds which exert an important influence on many of the physiological processes of the animal body and are as necessary as the other constituents of the ration.

They are used principally to aid digestion, to make bone, to provide the mineral matter in the milk, to build up the body, and to aid in the functioning of all organs in general.

Cows must have feed containing enough minerals of the proper kind or they will draw on their body stores and eventually decline in production. Other ill effects such as stiffness, enlarged joints, lack of appetite, depraved appetite, and cessation of oestrus can sometimes be traced to lack of minerals. In some sections pregnant cows fed rations deficient in iodine are likely to give birth to calves with goiter.

WATER

Water is the great carrier of food material within the body of the animal. It makes blood a fluid so that it can circulate. Many substances must be dissolved in water before they can be absorbed from the digestive tract. Waste materials are dissolved in water and eliminated as urine and perspiration. By its evaporation from the skin and lungs water controls body temperatures. Water, then, is a necessary constituent of practically all excretions or secretions, including milk. Animals will live much longer without food than without water.

VITAMINS

The term "vitamin" is a group name for certain substances, other than proteins, fats, carbohydrates, and minerals, which have been discovered to be necessary in animal nutrition. These vitamins occur in minute quantities in natural food materials. Those studied have been named A, B, C, D, E, and G. Vitamin B is sometimes called B₁ or F, and vitamin G is sometimes called B₂. Both of these vitamins were formerly called B. Most vitamins are recognized by their physiological effects rather than by their physical or chemical properties. Vitamins are essential to the life and health of animals.

Vitamin A appears to be the one most likely to be deficient in the ration of the dairy cow. This vitamin controls growth and influences resistance to infections. Carotene, the yellow pigment of the plant from which vitamin A is formed in the animal body, occurs in close association with the green coloring matter of pasture plants and other green forage and also with the green coloring matter of cured roughages, though in carrots and yellow corn it occurs in dissociation with the green color. As a rule the greener the color of the hay, the greater the content of carotene.

Ordinarily, silage made from fresh green plants and packed tightly enough to force out and keep out the air will have a high content of carotene. The green color of such silage may be greatly reduced in the fermentation process and the content of carotene still be high. The green color of silage, unlike that of hays, is a very imperfect indication of its carotene content. Fresh green forage, green-colored hay, and silage are the common sources of vitamin A for dairy cattle and herbivorous animals though cod-liver oil is often fed to certain smaller animals to provide vitamin A.

Cows fed for extended periods on a ration deficient in carotene or vitamin A may give birth to weak, dead, or premature calves. Although the quantity of milk produced by cows fed on a carotene-deficient ration may not be materially affected, the content of carotene and vitamin A in the milk is much reduced. Calves fed the milk from cows that have been on a carotene-deficient ration for some time

will cease to grow and will soon die unless they are given supplementary feeds rich in vitamin A or carotene. A reserve supply of vitamin A is stored in the liver and because of this cows may sometimes live for months on a ration deficient in vitamin A or carotene without any noticeably bad effects.

Vitamin D or some unidentified property of pasture grass, or of other green forage, or of hay cured with much of its natural green color, is useful in promoting the assimilation of calcium and the retention of calcium within the animal body. The other vitamins, if actually essential to the proper nutrition of dairy cows, have never been proved to be so deficient in any of the ordinary rations that their lack caused trouble.

Pasture grass or other green forage, silage made from a green crop, or a hay that has retained much of its natural green color, fed for at least a portion of the year, is essential to the continued well-being of dairy cows. Otherwise cows will suffer from a vitamin A deficiency and possibly also from a mineral deficiency.

PROCESS OF DIGESTION

The cow's stomach is divided into four compartments. Apparently cows chew their feed and mix it with saliva only enough to permit it to be swallowed into the large compartment of the stomach known as the rumen or paunch. This compartment acts as a reservoir and softens the coarse feed through the action of body heat and mixing with water. It appears also that the action of certain bacteria in the paunch may be beneficial.

Cows chew their cud and thus further reduce the size of the feed particles so that they may pass to the other compartments of the stomach. Any feed that is in a sufficiently fine state of division may pass on directly without being rechewed. The paunch is never empty; additional feed enters every time a cow eats, and the new and old materials are mixed. Although some of the roughage, such as hay, passes through the digestive tract in about 1½ days, some of it remains in the body for 10 days or more.

The next compartment of the stomach is known as the reticulum or honeycomb. Its contents are more watery than those of the paunch. Foreign material, such as gravel and pieces of metal, collects here and remains. Sometimes a sharp piece of wire or nail penetrates the wall of this compartment, with fatal results.

The third compartment is called the omasum or manyplies. Across it are divisions resembling leaves of a book, and it is between these leaves that the food passes. The contents of this compartment are much drier than those of the others.

Although some absorption of nutrients into the blood takes place through the walls of the first three compartments, the main function of these compartments appears to be the preparation of the food for the action of the fourth and last compartment, or true stomach, known as the abomasum. It is here that the digestive juices act on the proteins and convert some of them into a state in which they can be absorbed through the walls of the stomach.

The food then enters the intestines, where it is further acted upon by the bile, pancreatic juice, and other juices, which digest the fats and carbohydrates as well as some of the proteins. Most of the food absorption takes place through the walls of the intestines.

CHARACTERISTICS OF FEEDS

All feeds for dairy cattle are commonly assumed to fall into two general classes—roughages and concentrates. Roughages may be either green or dry. The fiber content of both green and dry roughage on the basis of dry matter is relatively high. Green roughages are pasture grasses or other fresh green forages, and closely related to these are the silages. Dry roughages are the hays, straws, fodders, and some of the byproducts from mills.

Concentrates are generally either the seeds of plants or the byproducts of such seeds when they are milled in the manufacture of human food or in the expression of oil. Byproducts of the dairy and meat-packing industries are also classed as concentrates. In fact, any material which has a low content of fiber when reduced to a dry basis is considered a concentrate.

HAYS

The importance of good hay can hardly be overestimated. By good hay is meant hay that has been cut early and cured in such a way that most of its leaves and much of its natural green color are retained. Such hay contains more protein, less fiber, more carotene, more leaves, and fewer stems than poor hay. It is also softer and more palatable. The mineral matter of green-cured hay is more completely used than that of hay which has become discolored through exposure to dew or rain.

Although legume hays are generally superior to the nonlegumes in content of protein and mineral matter and in palatability, much depends upon the soil on which the hays are grown and on the way in which they have been made. A grass hay, for instance, grown upon a soil that is rich in lime and phosphorus, cut early, and nicely cured, may be superior in many respects to a legume hay. A legume hay is not necessarily good merely because it is a legume, nor is a grass hay necessarily poor because it is a grass.

All dairymen, whether they raise their own hay or buy it, should be able to determine, by observation, the quality of the various classes and grades of hay, as given in the United States Department of Agriculture Handbook of Official Hay Standards, for 1932.

The following statement¹ made with reference to alfalfa-hay production and marketing may be applied in general to all hays:

(1) Early cut, leafy, and properly cured alfalfa from any region has more feed value than overripe, stemmy, and properly cured alfalfa from the same region or any other region; (2) alfalfa from any region, so cured as to retain a high percentage of leaves, has more feed value than alfalfa from the same region or any other region that was so cured as to shatter a high percentage of leaves from the stems prior to baling; and (3) early cut, leafy, and properly cured alfalfa from any region has more feed value than early cut, severely bleached, and rain-damaged alfalfa from the same region or any other region. Similar comparisons and conclusions may be made with respect to the feed value of various cuttings.

LEGUME HAYS

Legume hays appear desirable for the proper nutrition of the dairy cow when pasture or other green feed is not available. In most sections of the United States they yield more nutrients per acre than do nonlegumes and provide protein at a lower cost. Good legume hay

¹ U. S. Department of Agriculture, Bureau of Agricultural Economics. U. S. Standards Reflect the Approximate Value of Alfalfa, 5 pp. 1930. [Multigraphed.]

is cured so as to retain its green color, is fine stemmed, and contains a large proportion of leaves to stems. Twenty-eight pounds of alfalfa leaves contain as much protein as 100 pounds of stems. For supplying vitamins, good legume hay and silage take the place to some extent of fresh, green forage.

Alfalfa is the best hay for dairy cows (fig. 1). It is more palatable than clover, is more easily cured than the annual legumes, and when fed, is more completely consumed than is either soybean or cowpea hay. Wherever alfalfa grows successfully it should be raised in preference to any other legume.

Although cows will eat no more of the clovers than they will of the annual legumes, there is usually less waste in feeding the clovers on account of their finer stems. Because of their fine stems also they cure more readily, and are therefore less liable to damage from rains. The clovers are rather uncertain crops. The stand is sometimes poor, and they are subject to winterkilling. No doubt this fact is responsible for the usual practice of seeding timothy or other grass along with the clover for if the clover fails the grower still has timothy.

Either soybeans or cowpeas can be raised successfully over a wide range of climatic and soil conditions. They grow on soils containing less lime than will the clovers or alfalfa, and they are especially valuable as catch crops for hay. Soybeans, being more upright in their growth and thus more easily harvested, are usually preferred to cowpeas.

The lespedeza hays, both common and improved varieties, are coming into more general use in the South, especially on acid soils. They make excellent hay, and some very good yields on rich soil have been reported.

The first year's growth of the biennial sweetclover makes a very good hay. If allowed to reach considerable height before being mowed, however, it will be stemmy, and the leaves will shatter badly. The second year's growth should be used for pasture rather than as hay for the following reasons: (1) It grows so rapidly that in order to get a reasonably fine hay it must be cut very early in the season, when curing is difficult; and (2), while many farmers have successfully fed second year's growth for a long time, there are recorded instances in which such hay developed some substance during curing that prevented the normal clotting of blood from a wound and led to fatal internal or external hemorrhages in the animals. It is unsafe to dehorn animals that are being fed considerable quantities of such hay.

GRASS HAYS

Grass hays include timothy, redtop, bluegrass, Sudan grass, sorghum, and others. As a rule these hays are less palatable than legume hays and contain less protein and mineral matter, and therefore are not so good as legume hays for milk production. However, if the grass hays are harvested at an early stage of maturity and are properly cured, they may be equal to legume hay cut at the usual stage of growth in both palatability and content of protein. There is evidence, also, that a high nitrogen content of the soil caused by either the growth of legumes or the addition of fertilizer increases the protein content of grasses.



FIGURE 1.—Three sources of cheap feed for dairy cows: A, Pasture; B, alfalfa; C, corn for silage.
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GRAIN HAYS

Grain hays include those made from the small cereals, such as oats, barley, wheat, and rye. To make the best hay these cereals should be cut when the grain is in the milk. At this stage the cured leaves retain their green color and if carefully handled do not crumble badly. In composition the grain hays are similar to grass hays, being rather low in protein in proportion to the carbohydrates and fats. The awns on some varieties of barley and wheat make these hays decidedly undesirable for feeding.

MIXED HAYS

Although the Handbook of Official Hay Standards gives a specific definition of mixed hay, for the purpose of this discussion any combination of a grass and a legume is called a mixed hay. Its composition is influenced by the kind and relative quantities of legumes and nonlegumes which it contains, the stage of maturity when cut, and the manner in which it is cured. Although early-cut grass often contains as much protein as the legumes, it is safe to conclude that, on an average, mixed hays, when cut at the same or corresponding stage of maturity as the legumes, contain only about two-thirds as much protein as do the legumes.

The practice of using a mixture of legumes with some other crops is to be commended where because of soil conditions or habits of growth the legumes cannot be depended upon for hay when sown alone. Some of these mixtures are oats and vetch, wheat and vetch, oats and peas, Sudan grass and soybeans, as well as clover and timothy, and alfalfa and timothy. These can all be made into a good quality of hay.

STRAWS

The cereal straws are high in fiber, low in proteins and minerals, constipating, and lacking in palatability. Cows, however, will eat small quantities of these, especially oat straw, even when they have access to plenty of good hay. Probably the consumption of a small quantity is beneficial.

If there is a shortage of other roughages or they are high priced, the straws from the cereal grains may well be used more extensively than is the usual practice. If properly supplemented with feeds rich in protein and minerals, these straws can furnish the greater part of the roughage for dairy cows, particularly that for low producers or dry cows. Heavy milk production cannot be expected when cereal straw is the sole roughage.

Legume straws contain more protein and minerals than the cereal straws and for this reason are generally superior to the cereal straws provided they have been saved in good condition.

CORN STOVER

The edible portion of corn stover is similar to timothy or other grass hay in composition, effects, and value. If the corn is cut rather early and the stover is shocked or stored in such a way that it will not be leached by rains, it makes a fairly good feed.

One great objection to corn stover is the waste in feeding it. When it is fed without being chopped or ground the waste amounts to one-third to one-half the total. Chopping or shredding it improves the

completeness of consumption, and grinding it may put it in such condition that there will be no waste whatever. Corn stover dries out very slowly. If it is stored in a chopped, shredded, or ground condition before the moisture content falls to 20 percent or less, it will heat and mold. For this reason it must be chopped or ground as it is used, until the moisture content becomes low enough so that it can be stored without spoiling.

SORGOS AND GRAIN SORGHUMS

In the Southwest if the sorgos (sweet sorghums) are seeded thick enough in drills or broadcast so that large stems will not develop, they may be made into hay much the same as Sudan grass. However, if they are seeded in rows as is the usual practice in most places where they are grown, they cannot be made into hay as the stalks become too heavy. Usually sorgos are put up in cocks and allowed to remain in the field until needed for feeding.

What has been said regarding corn stover applies in general to the stovers of the grain sorghums. Both the sorgos and the grain sorghums are low in protein and should be supplemented with some feed or feeds richer in protein.

SILAGES

Any crop which contains enough fiber and neither too much nor too little moisture may be made into silage successfully. In general the silage will be similar to the crop material from which it is made in respect to both palatability and nutrients contained. Unpalatable or inedible materials cannot be made into satisfactory feeds by putting them in the silo.

Taking into consideration the yield, sureness of crop, ease of handling, and feeding value, corn is generally the best silage crop, although in certain regions where corn does not thrive the sorghums, small grains, and even sunflowers and Russian-thistles have proved to be more or less satisfactory substitutes. Grasses and legumes ordinarily used for pasture and hay are being made into silage successfully.

Crops put into the silo should be dry enough so that there will be little or no leakage of juices from the silo, and wet enough so that they will pack closely and force out the air. They should also be chopped fine to permit close packing. Legumes, and perhaps grasses also, should be allowed to wilt if necessary to bring the moisture content below 70 percent. If the crops are harvested during a dry period or in good drying weather, wilting may not be necessary.

The carotene content of silage has been found to be high if the crop from which it was made had a high carotene content and the silage was packed tightly enough to exclude the air. Crops that have become discolored by frost before being cut, or by rains or dews after being cut, will have a low carotene content, and the resulting silage will likewise be low in carotene. Because of its carotene content good silage is especially valuable as a supplement to hay that has become discolored as a result of late cutting, faulty curing, or storage with too much moisture. Silage from nonlegumes, if properly made, is palatable and has a good appearance and odor and a high carotene content. Under American conditions, there is no evidence that adding mineral acids or any other substance to such silage is

beneficial. To what extent mineral acids and molasses or other carbohydrate materials are useful in improving the quality of silage made from legumes is still undetermined.

SOILING CROPS

Soiling crops, which are harvested and fed immediately in their fresh green state, are valuable as substitutes for pastures or as supplements to them. A cereal, Sudan grass, or a legume, or a combination of the cereal or Sudan grass with a legume, is most commonly used, but any palatable green feed may be fed. Soiling crops are similar to pasture in nutritive value.

ROOT CROPS AND OTHER SUCCULENTS

Most of the common root crops, such as mangels, beets, rutabagas, turnips, and carrots, are valuable dairy feeds. Because they are low in fiber and high in water content these feeds are sometimes spoken of as watery concentrates. Materials which may be fed in the place of silage or the root crops are apples, apple pomace, pumpkins, cull potatoes, sweetpotatoes, kales, sugar-beet pulp, and wet brewers' grains. The value of each depends largely upon the content of dry matter. Wet beet pulp and pumpkins are low in this constituent, having only about one-third as much dry matter as sweetpotatoes and wet brewers' grains.

PASTURE

Pasture grass or other green forage appears desirable for continuous high milk production. Such material possesses a property which under certain conditions promotes the assimilation of mineral matter. A cow on good pasture is able to replenish the stores of minerals and vitamin A which are likely to have become depleted during the winter if an unsuitable grain mixture and a poor quality of roughage have been fed. Since pasture grass is bulky and watery, most cows are unable to eat enough of it alone to support a very large flow of milk. As the grass matures there is a steady decline in the percentage of protein and an increase in the content of dry matter and fiber.

CEREAL GRAINS

In general, cereal grains are palatable, rich in carbohydrates, low in fiber and minerals, comparatively low in protein, and high in total digestible nutrients. Corn stands at the head of the list in palatability and percentage of total digestible nutrients. Barley and the sorghums are almost as desirable in these respects. Oats have a higher fiber content than any of the other cereals but contain more protein than does corn or barley. Wheat is similar to corn, in composition and feeding value, and when the price of wheat per pound is less than that of corn it will pay to substitute wheat for at least a part of the corn in grain mixtures for dairy cows. Rye is high in content of nutrients, but because it lacks palatability it is used very little as a dairy feed.

LEGUME SEEDS AND OIL MEALS

The legume seeds and so-called oil meals contain much protein and have a high nutritive value. The legume seeds used for dairy feed include the field pea, velvetbean, soybean, and peanut. The oil of

the soybean and peanut is usually extracted and used commercially, the residue being used for feeding purposes. In that form they are similar in feeding value to linseed meal and cottonseed meal, which are also residues from the extraction of oil from the flaxseed and cottonseed, respectively. All these feeds except the velvetbean are palatable, but their high concentration makes it desirable that they be fed with more bulky material. Cottonseed meal contains a comparatively large percentage of phosphorus, linseed meal and soybean oil meal somewhat less, and peanut meal the least of all.

BYPRODUCTS

A number of byproducts are used for feeding, but only the most important ones are discussed here.

Wheat bran contains much phosphorus and a medium amount of protein and is bulky. These characteristics make it a valuable ingredient of all dairy rations.

Hominy feed is comparable with corn meal in nearly all respects. The two are thought to be equal in feeding value pound for pound. Hominy feed is not so likely to heat and mold as is corn meal.

Corn-gluten feed is rather high in protein, averaging 20 percent or more in the best grades. It is somewhat bulky and not quite so palatable as hominy feed and corn meal. Corn-gluten meal has a high content of protein and for that reason is sometimes used to replace the oil meals in the ration.

Dried brewers' grains are similar to corn-gluten feed in composition, but they contain more fiber and less total nutrients.

Dried distillers' grains if made from corn have a higher content of protein and total nutrients than brewers' grains. If made from rye, however, they are unpalatable and low in feeding value.

Coconut meal, which is widely used on the west coast, contains only a medium quantity of protein. Although it is not especially palatable, it is used to advantage as one of the ingredients of the concentrate ration. Its price, too, generally serves to make it attractive.

Tankage and fish meal are both being used successfully in the rations of dairy cattle. These feeds not only have a high content of protein but the calcium and phosphorus are also high, which makes them of especial value in a ration that otherwise is deficient in these essential minerals.

Dried beet pulp is low in protein, bulky, and fairly palatable. Apparently cows are unlikely to be injured by eating large quantities of the pulp which is one reason why beet pulp is so widely used in the rations of high-producing cows.

Both beet and cane molasses are very palatable and when mixed with some feeds ordinarily unpalatable cause such feeds to be eaten more readily and completely. Carbohydrates make up about two-thirds of the weight of molasses. Sometimes the price of molasses is so low that some feeders consider that the nutrient content alone justifies its purchase. Both kinds of molasses are laxative, that from the sugar beet being more so than that from the sugarcane.

COMMERCIAL MIXED FEEDS

Many excellent mixed feeds containing only high-quality ingredients are on the market. Laws governing the sale of mixed feeds require that their chemical composition be stated on the bags. An

examination of these analyses will enable the buyer to form a better opinion of the value of the feed. The lower the fiber content the more valuable the feed. A high fiber content indicates the presence of oat hulls, corncobs, cottonseed hulls, ground roughage, or other low-grade material. The analyses of many mixed feeds, however, do not give complete information on the composition—omitting for instance the sources of protein, or the content of phosphorus and calcium. Such formulas are known as “closed” formulas. The “open” formula, on the other hand, gives also the kind and quantities of the different ingredients in the mixture and thus helps the buyer to judge the value of the feed. If the analysis of a feed is satisfactory, if the variety of sources is ample, if the odor and appearance of the feed are good, and if the cows like it, the requirements for a good feed are largely complied with.

COMPOUNDING THE GRAIN RATION

In compounding the grain ration several factors besides cost must be considered. They are bulkiness, palatability, and the content of protein and minerals.

PROTEIN CONTENT

One of the most important considerations in preparing a grain ration is to see that it contains sufficient protein from a number of sources so that every cow will be amply nourished. It is impracticable, however, to furnish a perfectly balanced ration for each dairy cow in the herd because the requirements of the cows differ with their production. It is better to have some cows get more protein than they need than to attempt to supply a perfectly balanced ration for every cow. The quantity of protein that must be supplied in the grain depends upon the quantity of protein in the roughage. The approximate percentages of protein in the grain rations to be fed with different roughages are shown in table 1. There are hundreds of combinations that may be used; the mixtures shown in the table are made up of certain standard feeds. Other feeds may be substituted wholly or in part for the feeds specified.

TABLE 1.—*Grain mixtures having different protein contents to be fed with different roughages*

Roughage	Approximate protein content desired in grain mixture	Grain mixture			
		Ground corn	Ground oats	Wheat bran	Cotton-seed meal
	Percent	Pounds	Pounds	Pounds	Pounds
Legume hay alone.....	12	400	200	200	-----
Legume hay and silage or mixed hay ¹ alone.....	16	300	200	200	100
Mixed hay ¹ and silage.....	20	200	200	200	200
Grass hay and silage or either alone.....	24	100	200	200	300

¹ One-half grass and one-half legume.

Part or all of the corn in the mixtures in table 1 may be replaced by barley, wheat, kafir, spelt, or hominy feed. Part of the oats may be replaced by barley, wheat, kafir, spelt, hominy feed, or corn. Two parts of gluten feed or dried brewers' grains may replace one part of oats and one part of cottonseed meal. Linseed meal, peanut

meal, soybean oil meal, or fish meal, may be substituted for part or all of the cottonseed meal. High-grade tankage may be substituted for cottonseed meal at the rate of 2 pounds of tankage for each 3 pounds of cottonseed meal.

MINERAL CONTENT

The minerals most likely to be deficient in the ration are common salt, calcium (lime), and phosphorus. Add common salt to the grain mixture at the rate of 1 percent. In addition to this allow the cows access to salt at least once a day.

Although mineral mixtures are sometimes added to the grain ration, better results are obtained by making up the ration in such a way as to supply the needed minerals in the natural foodstuffs. None of the concentrates are high in lime. To provide this mineral, see that the cow receives plenty of legumes either in the form of pasture, soiling crops, or hay so cured as to retain its green color and leafiness. If the grain ration contains a liberal proportion of wheat bran or some of the oil meals the phosphorus needs of the cow will be met. Soils containing an abundance of lime and phosphorus will produce forage richer in these constituents than will soils deficient in them. For this reason liming and fertilizing the soil will go a long way toward maintaining proper mineral nutrition of the dairy herd.

Feeding inorganic mineral supplements containing calcium and phosphorus is advisable only under certain conditions. When cows are on grass pastures, the soils of which are poor in lime or phosphorus or both, some benefit is derived from feeding steamed bonemeal. Mix it with the grain at the rate of 1 or 2 percent. If the cows receive no grain while on pasture, put the bonemeal in a box where it will be accessible to the cows. In certain sections of the United States the soil is so deficient in phosphorus that feeding the forage produced thereon to dairy cows in the winter leads to serious malnutrition. This may be corrected by feeding steamed bonemeal.

Steamed bonemeal is valuable as a source of both calcium and phosphorus. Some bonemeals are steamed more than others. The more the meal is steamed the less the organic matter left in it and the less odorous the product. The cows greatly prefer the bonemeal which has been only slightly steamed, and for this reason it is the better form to use where cows have access to it at will. In any case the bonemeal should be steamed sufficiently to destroy any disease-producing organisms. Since such bonemeal spoils when it gets wet, the box containing it must be protected from the rain. When the bonemeal is fed in the grain mixture its palatability is not an important factor, and therefore it makes little difference which form of the product is used.

The use of complex mineral mixtures is not advised, since calcium and phosphorus, the only minerals likely to be deficient in the ration, can be obtained more cheaply in bonemeal than in the prepared mixtures. Raw rock phosphate may prove harmful because of its content of fluorine.

In addition to the minerals just mentioned, it is sometimes necessary in certain regions to supply iodine in the ration. This can be done effectively by sprinkling on the feed of the pregnant cow once each week a tablespoonful of a 5-percent solution of potassium or sodium iodide, or fish meal can be included as one of the constituents of the ration.

BULKINESS AND PALATABILITY

Some feeds become pasty when moistened; in this condition the digestive juices cannot readily act on them. Combine such feeds with more bulky ones in order to prevent this condition. The best feeds for this purpose are wheat bran and ground oats. If the grain ration contains one third to one half of either or both of these two feeds it will not stick together when wet. Dried beet pulp or a ground roughage may also be used for this purpose. In some cases the concentrates are mixed with the silage at feeding time. Cobs are sometimes ground with the corn in order to provide bulk in the grain ration. Although the cobs do serve this purpose, they add very little nutriment.

Grain mixtures should be sufficiently palatable so that every cow will consume as much as is required for highest milk production. Fortunately, most concentrates of good quality are palatable. Among these are corn, barley, oats, wheat bran, beet pulp, and the oil meals. Velvetbeans, rye, and some of the other uncommon feeds lack palatability.

Molasses is used extensively, especially in ready mixed rations, to make the mixtures more palatable. Dairy farmers use molasses also to render low-grade roughages more appetizing as well as to replace corn or other carbohydrate feed when the relative prices are favorable to molasses. Cows will eat low-grade hay more completely if molasses is poured over it. Before adding the molasses, mix with it enough water to make the solution flow freely. On account of the laxative nature of beet molasses 3 pounds per day for each cow is the maximum amount that can be fed safely. Cane molasses can be fed safely in larger amounts.

KINDS AND QUANTITIES OF FEED TO USE

In general, dairy cows should be fed all or nearly all the roughage they will consume in the form of pasture grass, soiling crops, hay, or silage. If such feeds are home-grown, the nutrients in them are usually cheaper than those in concentrates; the cow's digestive system is primarily adapted to handling coarse feed, and cows generously fed on roughage rather than concentrates are less subject to digestive disturbances. If the dairyman buys both the hay and the grain, however, and the hay costs more than two-thirds as much as the grain, he may well limit the quantity of hay and feed more grain. In feeding high producers, however, care must be taken not to feed concentrates too heavily and throw the cow off her feed. Such cows should receive enough nutrients in their roughages so that the grain allowance may be kept at a safe level. On the other hand, cows producing a small or medium quantity of milk may be fed on roughage alone if the roughage is of good quality and relatively cheap.

SUMMER FEEDING

Pasture provides the cheapest summer feed. This is because the labor cost of maintaining pastures is only a fraction of the labor cost of raising harvested crops.

Ideal pasture herbage is young, tender, abundant, and palatable, and is grown on a soil rich in minerals, especially lime and phosphorus. Immature grass not only has a higher protein content but also is

more palatable than that which has reached the usual haymaking stage. In many pastures cows will graze on the spots of short immature grass rather than on the grass that has become more mature. Early in the spring, although the grass is tender and palatable, it should not be grazed until it has made enough growth so that a cow can gather her fill in a few hours.

Pastures differ so much in quality that specific pasturing recommendations are impossible. On good grass pasture in many sections of the United States cows that are producing 1 pound of butterfat or less a day maintain their production and body weight for the first month or so just as well without grain as with it. But from this time until fall additional feed must be supplied because the grass becomes either less abundant or more mature, and the intake of grass is therefore much diminished. If the rainfall is sufficient to keep the pastures fairly abundant or if good temporary pastures are available so that the cows will always have their fill of roughage, grain alone will probably suffice as a supplementary feed. Under less favorable conditions, however, soiling crops, hay, or silage should be fed, in order to provide an adequate quantity of roughage.

In deciding on the kinds and quantities of feeds to be used in supplementing the pastures, the condition of the cows should be taken into consideration. In most cases, if the cows are allowed to become very thin, the result will be a much-reduced milk flow, which cannot be regained during that lactation period by subsequent more liberal feeding.

Soiling crops are often used as supplements to short pastures and sometimes as substitutes for them. For the former purpose corn and, to a lesser extent, alfalfa, soybeans, or Sudan grass are the most generally used. Since these crops are rather generally raised on dairy farms, they may require no additional fields or special attention. Therefore, they make the cheapest and best soiling crops for use late in the summer. When soiling crops take the place of pasture entirely, a continuous supply of them must be provided throughout the summer, a fact that necessitates special crops or special seedings to fill the gaps between the crops regularly raised. The crops to be raised differ so much with climatic and soil conditions that specific recommendations for them are not possible.

For summer feeding, silage, where it is available, is generally cheaper and more convenient to use than are soiling crops. Silage left over from the previous season may be fed after the spoiled top layer has been removed, an early maturing crop may be ensiled and used as needed, or silage made from the early growth of grass may be used for feeding when the pasturage becomes inadequate. Hay may also be used to supplement pastures, particularly if the nutrients in the hay are obtained at a relatively low cost.

The crops to be used for supplemental pastures depend largely on the season at which such pastures are needed and on the adaptability of the crop to the section where it is to be grown. Sudan grass is perhaps used more than any other crop as a supplemental pasture, although in the southern half of the United States lespedeza is rapidly coming into more general use. One of the advantages of lespedeza is that it does not require reseeding every year. Sweet clover in the Midwest and the aftermath of hayfields in the Northeast are being used extensively for supplemental pasturage. In some sections the

small grains provide pasturage during the colder seasons of the year when the permanent pastures are dormant. Alfalfa also is coming into more general use as a pasture crop in many sections of the United States. More complete information regarding pastures is contained in Miscellaneous Publication 194, A Pasture Handbook, issued by the United States Department of Agriculture.

WINTER FEEDING

In winter the cows should be given all the good hay they will eat, twice a day. If they will eat corn stover or straw in addition, there is no objection to letting them have it. When the hay is fed with a medium quantity of silage, 1 to 1½ pounds a day of medium to good hay for each 100 pounds of live weight will be consumed. The same quality of hay fed without the silage will be eaten at the rate of 2 pounds a day for each 100 pounds of live weight. More nutrients are consumed when silage or roots are fed with the hay than when hay is fed alone, if the hay is of medium or poor quality. However, if the hay is of the best quality more nutrients may be consumed than if a portion of it is replaced by silage. No. 1 alfalfa hay, fed as the sole ration and to the limit of the cows' appetites, will be consumed at the rate of 3 pounds or more of hay for each 100 pounds of live weight.

In most sections of the United States the silo is the cheapest, surest, and most satisfactory means of providing a succulent feed for winter use. The amount of silage to be fed ranges from about 20 pounds per cow per day to 50 pounds per cow per day, depending on the size of the cow and the quantity of other roughages fed. If hay is scarce or high-priced, reduce the amount of hay and feed more silage. The usual quantity of silage advised is about 3 pounds per day for each 100 pounds of live weight.

Although root crops are low in fiber, they should not be fed in place of concentrates but, like silage, as a supplement to a ration of hay and concentrates. The quantity of root crops to feed depends upon their cost as compared with that of other feeds, upon the kinds of roots, and upon the other ingredients in the ration. In general, cows receiving such feeds as pasture, soiling crops, or silage do not need root crops. If root crops are expensive, feed only about 30 to 50 pounds a day. If relatively cheap, as may be the case in some regions, feed twice this quantity. More mangels and turnips than sugar beets or sweetpotatoes may be fed because they contain more water. Feed only moderate quantities of beet tops, because they are more laxative than the beets themselves. Beet tops as well as the root crops should be free from excessive dirt when fed.

Frequently the grain requirement for high-producing cows is so great that the necessary quantity cannot be fed without endangering their health. In such cases the quantity of grain may be kept at a safe level and the additional nutrients supplied by feeding beet pulp either dry or soaked in about three times its weight of water.

Experiments at the dairy experiment farm at Beltsville, Md., show the following feeding practice to be fairly satisfactory: Feed each cow about 3 pounds of silage for each 100 pounds of live weight. A cow weighing 800 pounds, therefore, would receive 24 pounds of silage, whereas one weighing 1,200 pounds would receive 36 pounds of silage. Twice a day give the cow all the good hay she will eat, ex-

clusive of coarse stems and weeds. To Jersey cows yielding 10 pounds of milk or less give no grain, but for every pound over 10 give 0.5 to 0.6 pound of grain. A Jersey cow giving 20 pounds of milk, therefore, would receive 5 or 6 pounds of grain; one giving 30 pounds of milk would receive 10 or 12 pounds of grain. To Holsteins yielding 16 pounds of milk or less give no grain, but for every pound over 16 give 0.4 pound of grain. A Holstein cow yielding 30 pounds of milk, therefore, would receive 5.6 or approximately 6 pounds of grain, whereas one giving 40 pounds would receive 9.6 or approximately 10 pounds of grain.

Although this system of feeding has not been tried out with other breeds, it is probable that Guernseys should receive about 0.5 pound of grain for each pound of milk above 12 and Ayrshires 0.45 pound of grain for each pound of milk above 14. If the hay is of poor quality the cows will not eat so much of it and therefore must have more grain. On the other hand, if the hay is of the best quality the cows will eat more of it, and less grain than specified will be required. If the roughage is the very best, a cow may produce 1 pound of butterfat daily, or even more, on roughage alone, without losing weight. The above directions are based on the supposition that the cow eats at least $1\frac{1}{4}$ pounds of hay per day for each 100 pounds of live weight. In the absence of exact weights, a feeder must be guided largely by the condition of the individual cows. If any are getting thin, give them more grain; if they are getting fat, reduce the grain. For most economical production, cows should be kept in a medium state of flesh, neither fat nor thin.

Record the quantity of feed consumed by each cow. A convenient and practical way to feed concentrates is to use a cart or truck to which are attached feeding charts or cards showing the amount of feed to be given each cow. A small blackboard can be attached to the cart and the figures recorded. A spring-balance scale suspended above the cart on an arm is of great help. If the allowance of silage and hay is weighed occasionally, the quantity can be measured with reasonable accuracy.

BEFORE AND AFTER CALVING

The cow that has been dry for 6 weeks to 2 months and has been liberally fed while milking, as well as during the dry period, should be in good flesh at calving time. Ground oats mixed with wheat bran and linseed meal are good feeds to use before calving. The drinking water should not be too cold.

For a few days after calving, cows should be fed sparingly. This will help to prevent digestive disturbances and to reduce the swelling in the udder. In general, after calving the appetite of thin cows is somewhat keener than that of fat cows, and their udders reach normal size in a shorter time. For these reasons the rations of thin cows may gradually be increased to the full amount in about 2 weeks and those of fat cows in 4 weeks or more.

After a cow has been fresh from 3 to 6 weeks, her weight has usually reached the minimum and her production the maximum. Thereafter feed her enough to maintain her body weight as well as to produce milk; otherwise the production of milk will decrease rapidly. She should make a slow but steady gain in weight from this time until she calves again in order to bring her to the same condition as that

of the previous year. The total gain, including the weight of the fetus, should be from 100 to 250 pounds, depending upon the breed and condition of the cow. It is better to feed her enough to allow some of this gain to be made while milking rather than to try to accomplish it all during the dry period. Such feeding will undoubtedly result in more milk than if the weight is kept stationary. The feeding practice recommended above will furnish sufficient nutrients for cows to make a slight gain but still not enough to bring them back to proper weight before drying off. Some of the flesh must be put on when cows are dry.

FEEDING SUGGESTIONS

Keep cows on good succulent pasture as much of the year as possible.

The order of feeding roughage, succulents, and concentrates has no effect on milk production.

Feed concentrates as often as the cow is milked. Roughage and succulents may be fed twice a day.

Feeding concentrates wet has no advantage over feeding them dry.

Always grind or roll grain for dairy cows.

Beet pulp may be fed either dry or soaked. If water is added, soak at one time only as much pulp as can be fed in 24 hours.

Cows will eat more of a coarse, stemmy hay if it is run through a cutter, although the digestibility of the feed is not affected.

There is no advantage in mixing ground roughages and ground concentrates except that a small quantity of ground roughage may be used to lighten a heavy ration of concentrates.

Corn fodder cut and treated with a converter, which changes some of the starch to sugar, has been found to possess no advantage over corn silage in cost, palatability, or effect on quantity of milk produced.

Always feed highly flavored feeds just after milking. It is advisable to do all the feeding at this time.

Before feeding such feeds as root crops, potatoes, and apples, run them through a feed chopper in order to prevent choking.

Shredding corn stover adds to the convenience in feeding, lessens the waste, and makes the portion refused better for bedding.

A cow not in good condition because of disease may be helped by a tonic. The tonic is a medicine and should be used as such. A healthy, well-fed cow needs a tonic no more than a healthy person needs medicine.

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1627

THE HESSIAN FLY AND HOW LOSSES FROM IT CAN BE AVOIDED



THE HESSIAN FLY undoubtedly is the most injurious insect enemy of wheat in the United States. During the last 45 years at least eight general outbreaks of this pest have occurred in the States east of the Mississippi River. These invasions have averaged about one every five or six years, although they have occurred at rather irregular intervals. A very destructive one was at its height during the period from 1914 to 1916. Serious and widespread injury occurred again in 1919 and 1920.

Local outbreaks occur nearly every year. In 1927 the loss in Kansas was estimated at 20,000,000 bushels, and material injury occurred the same year in the Middle Atlantic States. The average annual damage to wheat throughout the United States has been estimated at many millions of dollars.

A large part of such losses is preventable, although no remedy is known which will destroy the pest or save the crop once it has become thoroughly infested. Control and preventive measures are described on pages 11-13 and summarized on page 14.

This bulletin is a revision of and supersedes Farmers' Bulletin No. 1083, The Hessian Fly and How to Prevent Losses From It.

Washington, D. C.

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THE HESSIAN FLY¹ AND HOW LOSSES FROM IT CAN BE AVOIDED

By W. R. WALTON and C. M. PACKARD, *Senior Entomologists, Division of Cereal and Forage Insects, Bureau of Entomology*

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ECONOMIC IMPORTANCE

IN THE PRINCIPAL winter-wheat-growing regions of the United States the Hessian fly is the most injurious insect enemy of the wheat crop. It occurs throughout this territory, except in the extreme southwestern part, and is always alert to take advantage of favorable weather and crop conditions to multiply rapidly. Damage amounting to at least \$100,000,000 in a single year has been known to result from its work.

The Hessian fly is injurious chiefly to wheat, but at times injures barley and rye to a lesser extent. It does not attack oats at all. In a few instances the insect has been reared from grasses, but it is not known to infest them heavily.

Its common name was bestowed upon this insect long ago by Americans because of its depredations on Long Island, N. Y., in 1779, in the vicinity of Lord Howe's encampment of three years before. On the supposition that the pest had been brought from their native country in the straw used for their bedding by the obnoxious Hessian mercenaries who constituted a part of this army, it was given the name of "Hessian fly." The pest is generally believed to have crossed the Atlantic some time in the latter half of the eighteenth century.

¹ *Phytophaga destructor* Say; order Diptera, family Itonididae.

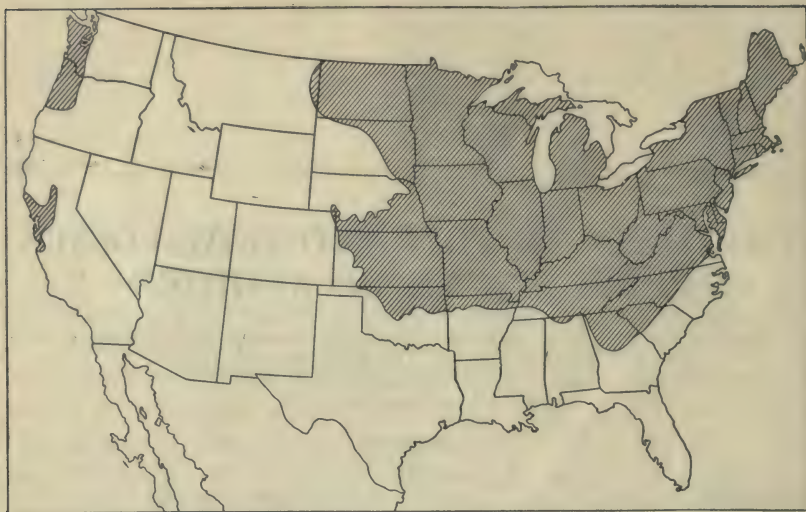


FIGURE 1.—Map showing distribution of the Hessian fly in the United States

REGIONS WHERE THE HESSIAN FLY IS MOST INJURIOUS

The present preferred home of the Hessian fly, generally speaking, is that portion of the country lying east of the one-hundredth meridian and between the thirty-fifth and forty-fifth parallels of north latitude. It is found outside of this area, but usually not as

a serious menace to the wheat. The fly also is found in the Pacific coast region, but is not nearly so destructive there as it is east of the Rocky Mountains. The map (fig. 1) shows the distribution of the insect in the United States.



FIGURE 2.—Healthy young wheat plant

The fly is also found in the Dominion of Canada from Prince Edward Island over most of Manitoba to Moose Jaw, Saskatchewan, and in British Columbia. Outside of North America, it is known in northern Africa, western Asia, Europe, Great Britain, and New Zealand.

NATURE OF INJURY

The injury by the Hessian fly to wheat and other grains is caused by the feeding of the maggots located between the leaf sheaths and the stems. They extract the juices of the young growing stems, causing the death of small tillers, and so weakening the older stems at the point of attack just above the joints that they break over shortly before harvest when the heads have grown heavy with grain. In cases of serious infestation much of the young wheat is killed outright by the work of the fall brood. The maggots of the spring brood may also kill out the plants in the same way, but the most obvious damage that they do is to cause the breaking over or "lodging" of the stems after these have developed heads. Not only is the quality of the grain reduced, but many such heads fall below the point where they can be taken up by the harvesting machinery.

EFFECT OF LARVAL FEEDING ON THE PLANT

The effect of the feeding of the larvae on a young wheat plant is very marked and may be observed soon after the young reach the stem under the sheath. Once an infested plant has been seen, it is usually possible afterwards to detect other infested plants.

For comparison, illustrations are given of a normal young plant (fig. 2) and of an infested young plant. (Fig. 3.) An uninfested plant is of a more slender growth, the green color is lighter, the stems are more or less visible, and the central unrolling leaf is present. The leaves are inclined to droop, and the tillers spread out and cover the ground. In an infested tiller the leaves are more erect, broader, and usually shorter, and of a darker green. Tillers infested in the fall usually perish during the winter.

Figure 3 shows a young tiller starting out from below the part attacked by the fly. If this is attacked after it appears above ground it assumes the same appearance as the original shoots. Its leaves become broader and of a darker color. This applies equally to a severe attack on fall wheat in spring or on young spring wheat.



FIGURE 3.—Young wheat plant infested by the Hessian fly

Although the spring wheats have a more upright habit of growth, and the hard wheats are naturally a somewhat deeper green, the more erect, shorter, darker leaves of infested plants will still enable the observer to detect the infestation. Later on the infested tillers



FIGURE 4.—Diagram showing seasonal development of the Hessian fly

change to yellow and then to brown, but the darker color and coarser growth of leaf always precede this. The presence of little greenish-white maggots or brown flaxseeds under the leaf sheaths, just above the bases or joints of the affected stems, is definite evi-

dence that the symptoms just described are caused by the Hessian fly.

LIFE HISTORY

In the winter-wheat regions of this country the Hessian fly has two principal generations annually—one in the spring and one in the fall. (Fig. 4.) In the South the spring generation becomes active earlier and the fall generation continues its activity later in the season than in the North.

Throughout the winter-wheat-growing regions the fly passes the winter in the young wheat, mostly in the resting or flaxseed² stage, but in mild winters it may hold over to some extent as larvae from two-thirds to full grown.

In spring (from March in Georgia and South Carolina to May in Michigan) the flies escape from the flaxseeds in the young plants, deposit their eggs on the wheat (fig. 4, upper leaf), and the young from these develop to flaxseeds (fig. 5) before harvest and pass the summer in the stubble.

In some seasons there appears before harvest a so-called "supplementary" brood of flies composed of delayed individuals from some of the overwintering flaxseeds and of flies from some of the newly developed spring puparia. Sufficient rainfall and humidity to cause germination and vigorous growth of volunteer wheat during the summer may also cause the development of a late summer brood of flies for which the volunteer wheat serves as a breeding place. Such infested volunteer wheat thus becomes an additional source of flies which infest planted wheat in the following fall or spring.

In the fall, under normal weather conditions, adult flies begin to come out of the stubble in late August and early September. Stragglers may continue to issue as late as the first of December in the latitude of Georgia and South Carolina, but in the most northern States the lower fall temperatures usually stop the emergence of flies in any great numbers before the end of September. Although adults may emerge in varying numbers during a period of several weeks, most of them usually appear and disappear within the space of a week or so—early enough in the fall for wheat planting to be safely delayed until serious danger of infestation is past. The flies prefer to deposit their eggs on the younger plants, those having from one to three leaves seeming to suit them best. The fall brood of young maggots hatching from these eggs make their way downward nearly or quite to the root crowns. (Fig. 5.) Normally they complete their development as larvae, pass into the flaxseed stage, and spend the winter as such on the young wheat plants. (Fig. 5.) The earliest deposited eggs on the earliest sown wheat, however, under favorable conditions may produce adults before the winter sets in, and in this

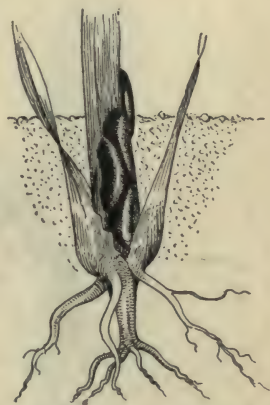


FIGURE 5.—Hessian fly flaxseeds on young wheat. Twice natural size.

² The so-called flaxseed of the Hessian fly is described in detail on p. 7.

case the delayed individuals emerging from stubble or volunteer wheat at this time combine with them to produce another so-called "supplementary generation." The importance of this supplementary generation depends largely on the weather. When winter sets in before the larvae have matured sufficiently to withstand its rigors, these necessarily perish, but if the mild fall weather is greatly prolonged, a greater or less number of them may winter over uninjured.

DESCRIPTION AND LOCATION OF VARIOUS STAGES

The egg is very minute, being only about one-fiftieth of an inch in length, but it may be readily seen by one having ordinarily good

sight. It is slender and almost cylindrical, with both ends bluntly rounded. The surface of the egg is glossy and of a pale red, which deepens with age. The eggs are usually placed in the grooves of the upper surface of the leaves.

The newly hatched larva, or maggot, is about the same size as the egg and has the same general color, but this changes to white within a few days. Immediately after it is hatched it makes it way down the leaf and behind the sheath. In the case of young wheat it descends to just above the roots, but after the plants have begun to joint it can go no farther than the base of the sheath belonging to that particular leaf, which is always at a joint. Where excessively abundant many larvae crowd together side by side

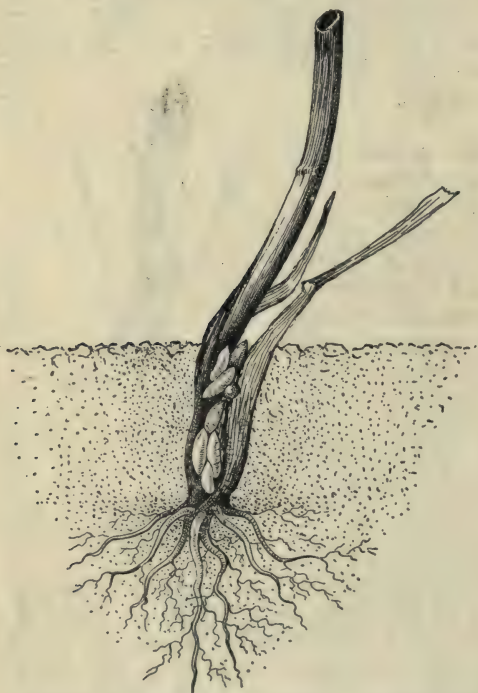


FIGURE 6.—Hessian-fly maggots beneath leaf sheath in the soil. Natural size

or behind one another under the same sheath. This condition usually accompanies a heavy infestation.

The fall brood of larvae and the overwintering flaxseeds are to be found just above the roots and below the surface of the ground. (Fig. 6.) In the spring generation the larvae and flaxseeds are to be found in different locations, depending upon the maturity of the plants at the time the infestation occurs. In case the flies emerge before the joints have begun to form in the wheat stems, the larvae and flaxseeds locate under the leaf sheaths arising from the bases of the stems. (Fig. 6.) When the adults emerge after the stems

have begun to form joints, many of the larvae and flaxseeds become established just above the joints under the leaf sheaths arising from those joints.

When the larva becomes full grown it is naked, glistening, and flaky white, with a translucent, greenish stripe down the middle of the back where the stomach contents show through. (Fig. 7.) The skin soon hardens and turns brown, forming what is called a puparium. The insect then quite closely resembles a flaxseed (fig. 8), and often is referred to by that name. This is not the pupa (fig. 9), which is formed subsequently after the larva has reversed its position inside the flaxseed and lies with the head pointing upward.

If the flaxseed is not situated conveniently for the emergence of the adult the pupa pushes itself, if possible, to a point of escape, and frequently the empty pupal skins may be observed protruding from under the sheaths of leaves.



FIGURE 7.—
The Hessian-
fly larva be-
fore flaxseed
is formed.
Magnified 12
diameters



FIGURE 8.—
The Hessian-
fly puparium
or flaxseed.
Magnified 12
diameters



FIGURE 9.—
The Hessian-
fly pupa re-
moved from
the flaxseed.
Magnified 12
diameters

The adult fly is not easily observed until one becomes familiar with its appearance and looks for it at the right time. It is very minute and somewhat resembles a small mosquito (figs. 10 and 11), but other gnats common in wheat fields may be easily mistaken for it. Many entirely different species of insects seen in the fields by growers are often incorrectly assumed to be the Hessian fly. During warm days in the egg-laying season, the flies may be observed flying about in the young wheat and alighting and laying eggs upon the leaves. On cooler days, or in early morning when there is a heavy dew, they are down among the leaves or even on the ground. The adult flies live only a few days, the period depending somewhat upon temperature conditions.

RELATION OF THE WEATHER TO THE HESSIAN FLY AND ITS CONTROL

All who have studied the Hessian fly carefully under various field conditions during a series of years have noted that weather condi-



FIGURE 10.—The Hessian fly: Adult female. Magnified 11 diameters



FIGURE 11.—The Hessian fly: Adult male. Magnified 11 diameters

tions have an important influence on the insect, and in the application of preventive measures these weather conditions become of vital importance.

Many wheat growers believe in the effectiveness of cold weather, or even of frosts, in terminating the activities of the flies in the fall and try to delay wheat sowing until after there has been a sharp frost. There is some ground for this belief, since emergence of flies already in the pupal stage, egg laying, and development of the young maggots, are retarded by such low temperatures. Also, maggots which have not already begun pupation inside their flaxseeds will not do so while the average daily temperature remains much below 50° F. Warmer periods during the fall, however, may allow considerable fly activity. Egg laying sometimes takes place in rather chilly weather, and the eggs have been known to remain in a temperature of 36° for several hours with no other effect than to delay their hatching that much longer. Eggs have been observed hatching in the daytime in fields when there were frosts nearly every night. Though the freedom of late-sown wheat from attack by the fly may be attributed partly to the advent of frosty weather, it should be understood clearly that this freedom is due largely to the fact that most of the adult flies usually are dead by the time severe frosts normally occur.

The most marked influence of climatic conditions on this insect is seen in the effect of heat and drought, and especially of the two combined. The larvae in the flaxseed form have been known to survive for more than two years under dry conditions and afterwards emerge as adults. Drought delays the emergence of the adult flies in the fall. This fact is of special importance in the North, where it is necessary to get the wheat sown early to enable the plants to withstand the severe winter weather. But extreme summer heat combined with dryness prevents this insect from surviving in the more arid wheat-producing regions of the West and Southwest.

Many years ago it became definitely known that wheat sown on or after certain dates in the fall usually escaped infestation by the Hessian fly. It was established that these dates varied with latitude and elevation, becoming earlier at a more or less uniform rate as one progressed northward or upward. In more recent years the best average safe dates in most States have been determined for different localities from a series of sowings on different dates in each locality, repeated annually for a number of years. In some States, also, the best dates to begin sowing are determined each fall by continuous observation of fly activities in several localities, the farmers being advised not to begin sowing until this date is determined, and being informed promptly as soon as it has been ascertained. The wheat grower should obtain the safe-sowing date for his locality from the county agricultural agent or the nearest experiment station.

NATURAL ENEMIES

There can be no doubt that parasites play a very important part in the natural control of the Hessian fly. Twenty-nine species of insects are now known to be parasitic on the immature stages of the fly in this country, but many of these species are rather rare. Figures

12 and 13 show two of the most common ones. Though 75 per cent or more of the flaxseeds are sometimes killed by parasites during the summer, the reproductive ability of the fly is so great that, given



FIGURE 12.—*Platygaster hiemalis*, a parasite of the Hessian fly. Enlarged 38 diameters

favorable weather conditions, a serious infestation may still develop in the following crop of wheat. Parasitism often helps materially to reduce the intensity of the Hessian-fly infestations, but ordinarily

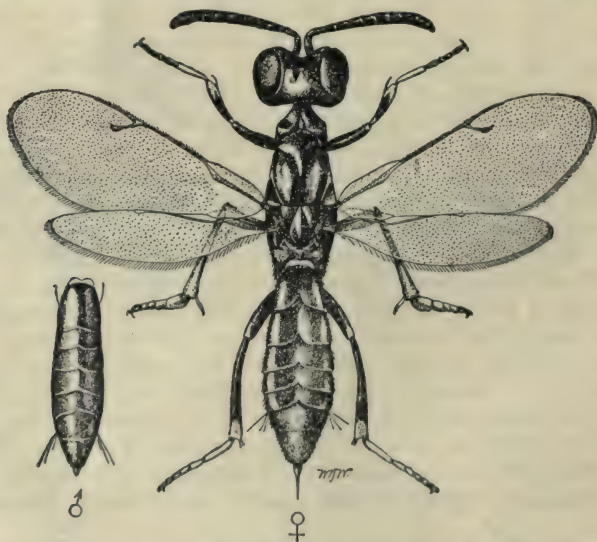


FIGURE 13.—*Eupelmus allynii*, a parasite of the Hessian fly: Female, with abdomen of male shown at left. Enlarged 20 diameters

it is not the controlling factor influencing fly abundance. No way has been devised of artificially increasing the effectiveness of parasites, and they can not be relied upon for certain help. Hence it

is necessary for wheat growers to practice at all times the preventive measures recommended in the following pages.

CONTROL MEASURES

USEFUL MEASURES ALL PREVENTIVE

Of direct remedies for the Hessian-fly injury there is little to be said, since after the pest becomes established in a field it can not be reached by any measure likely to destroy it. All useful measures yet known are in the nature of preventives, keeping the pest from attacking young wheat in the fall, and increasing the vigor of the young plants in order to enable them to counteract the insect's effect when present. Under the first category come late sowing, rotation of crops, the plowing under of stubble, and the destruction of volunteer wheat. Under the second should be classed the enrichment of the soil, its thorough preparation, and the selection and proper sowing of the best seed.

CROP ROTATION DESIRABLE

For Hessian-fly control wheat should not be grown on the same land two years in succession where it is practicable to avoid this, as the continuous planting of wheat increases infestation not only by the Hessian fly but also by other insect pests which infest wheat stubble, such as the jointworm, the strawworm, and the wheat-stem sawflies. Such a rotation of crops should be practiced as is approved by local farm advisers or State experiment stations.

PLOWING DOWN STUBBLE BENEFICIAL

Where it can be practiced the plowing under of stubble soon after harvest has been found to aid greatly in reducing the abundance of the pest. Plowing must be deep and thorough to be effective, and the surface should be harrowed or rolled afterwards to close the openings in the soil and prevent the flies from emerging. While this method of control is not advised for regions where the best crop rotations call for the sowing of grass and clover in the growing wheat, it is practicable in most of the great wheat-growing area west of the Mississippi River. The plowing under of the stubble as soon as possible after harvest, followed by proper cultivation to keep down volunteer growth, not only reduces the fly menace but improves soil conditions for the following crop so that the yield is increased. The practice is highly recommended wherever cultural conditions will permit.

DESTRUCTION OF VOLUNTEER WHEAT FATAL TO THE FLY

Volunteer wheat serves as a breeding place for the Hessian fly between regular crops and should be eliminated wherever possible by disking, plowing, or some other method.

This is a very important and valuable measure in Hessian-fly control and can be accomplished by the same cultural operations used for eliminating the stubble. The destruction of volunteer wheat, like the plowing under of stubble, is not practicable in those regions where grass and clover are sown in the wheat, but by all means it should be practiced wherever possible.

PROPER PREPARATION OF THE SOIL IMPORTANT

It matters little whether a soil has much or little fertility if that fertility is bound up in clods or hard lumps out of reach of the rootlets of the young plants. Early plowing and thorough working and compacting of the soil eliminate the lumps and clods and produce a finely pulverized, compact, moisture-conserving seed bed, from which, as soon as rootlets are sent out from the seed kernel, the shoot begins to draw nourishment. This condition gives vigor to the plants and thus enables them, by freely tillering, to outgrow a light attack of the fly that otherwise might prove serious.

CONSERVATION OF MOISTURE AIDS GERMINATION

The seed bed should be prepared in advance of seeding. If rain occurs before the date set for sowing, the ground should be harrowed to conserve the moisture so that the wheat will germinate promptly even if the weather should turn dry. This is an important point frequently overlooked by growers.

THE USE OF GOOD SEED ESSENTIAL

As the seed kernel must contain sufficient nutriment to sustain the plant until it can support itself by drawing from the soil, any deficiency in the seed necessarily tends to weaken the plant at the very beginning of its existence. Thus good seed becomes the first requisite in securing the healthy, vigorous plant that is to be further strengthened and sustained by a well-prepared, fertile soil. It is clear then that all shrunken, dwarfed, or otherwise imperfect kernels or weed seed, especially cockle, should be cleaned out of the seed before it is sown and only the largest and most perfect grains retained.

ENRICHING THE SOIL MAKES VIGOROUS WHEAT

Wheat growing in fertile, rich soil withstands both Hessian-fly and jointworm injury much better than that growing in poor soil. Therefore keep the soil of wheat land in good tilth at all times by following the methods approved by agricultural experts for your particular locality.

DATE OF SOWING TO ESCAPE INJURY

Late sowing as here recommended means moderately late sowing of fall wheat in any locality, because extremely late sowing, which sometimes has been advised, is even worse than early sowing. Experiments conducted over a period of many years have shown that in most localities the safe date for sowing winter wheat to escape Hessian-fly injury in years of normal rainfall usually coincides fairly well with the proper time for sowing in order to secure maximum yields of grain. The best average dates to begin sowing wheat in order to avoid the Hessian fly in different parts of the winter-wheat belt are shown in Figure 14. In a normal year wheat sown during the 10-day period immediately following these dates stands the best chance of escaping injury by both fly and winter killing.

The dates shown are only approximate and serve to indicate about the time when the fall brood of the fly has disappeared. Farmers should consult the county agricultural agent or nearest experiment

station to obtain additional information on the safe-sowing dates recommended for their immediate localities. All are dependent upon latitude, altitude, longitude, weather fluctuations, and other local conditions. The date varies considerably in broken or hilly country, even on the same farm, being appreciably later on the southern slope of a hill than on the northern slope of the same hill. Because of the fact that the larger part of the fall brood appears and is gone within a week or so, it is possible so to time the seeding of winter wheat as to avoid the Hessian fly, and this is one of the most practical and effective measures that can be applied.

COOPERATION NECESSARY

Though much benefit may accrue to individual farmers from the use of the control methods now available, the full value of most of them can be secured only by their adoption throughout whole neighborhoods.

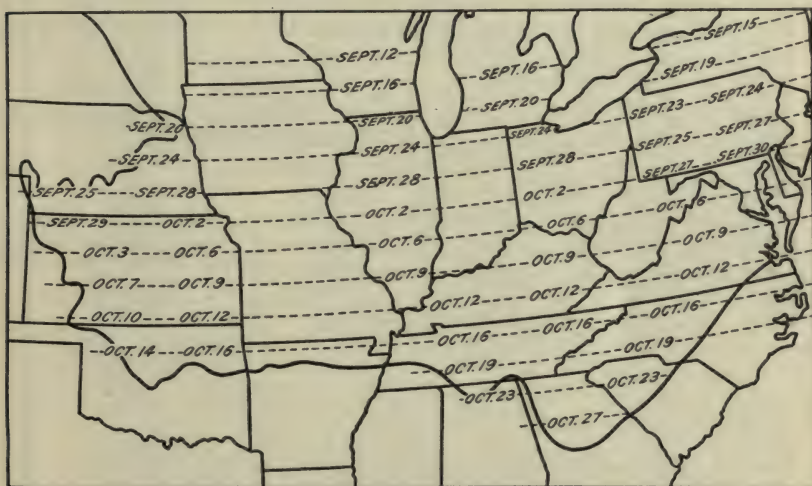


FIGURE 14.—Map showing the earliest safe-sowing dates to avoid injury by the Hessian fly. These dates are only approximate. Farmers should consult their county agricultural agent or nearest experiment station to obtain more exact information on the safe-sowing dates recommended for their immediate localities.

borhoods. Though one farmer may prevent infestation from originating in his own fields, his young wheat may still be injured by flies emerging from his neighbors' fields unless they too have taken steps to prevent it. Cooperation is essential to prompt and effective reduction of Hessian-fly outbreaks.

IMPRACTICAL MEASURES FOR CONTROL

Many expedients which have been suggested for the control of the Hessian fly are useless or of very doubtful value. Burning the stubble to kill the flaxseeds; rolling, pasturing, or mowing the young wheat to kill the immature stages of the insect; and early planting of trap strips or decoy plots of young wheat to concentrate the flies for destruction later by plowing the strips under, have all been proven by experience to be ineffective or impractical.

SUMMARY OF CONTROL MEASURES

There is no remedy for the Hessian fly when once it has taken possession of a crop of wheat. Injury can be prevented in only one way, namely, by keeping the fly out of the wheat. The following methods are reliable and should all be observed where it is possible to do so.

(1) Practice crop rotation. Do not sow wheat on wheat stubble if it is possible to avoid doing so.

(2) Plow under all infested stubble, where practicable, soon after harvest. Plow under ruined wheat as soon as possible after it has become certain that the crop will be a failure.

(3) Destroy all volunteer wheat where possible, by harrowing, disking, plowing, or some other method.

(4) Plow all land to be sown to wheat as early and deeply as existing conditions permit, and prepare a thoroughly pulverized and compacted seed bed.

(5) Conserve moisture against a period of drought at seeding time.

(6) Use good seed.

(7) Fertilize.

(8) Sow wheat during the fly-free period as advised by your county agricultural agent or State experiment station.

Adhere to these practices every year whether the fly is abundant or scarce. They will help to keep it scarce.

Finally, cooperate. Without community cooperation success can not be attained, because one infested field may furnish enough flies to damage the wheat in several near-by fields.

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1628

GROWING BLACK LOCUST TREES



TREES PRODUCING WOOD that is durable when used in the ground are in special demand. Among the few native trees of this kind the black locust ranks very high. It is much in demand for use as fence posts, stakes, and poles.

Black locust has a strong, spreading root system which makes it of much value in checking erosion. Probably no other forest tree is being planted so extensively for erosion control. It is a legume, which in part accounts for its power of growth in lean soils and makes it an outstanding soil builder.

A serious menace, however, to the growth of black locust is an insect known as the locust borer. Yet in many localities black locust can be grown successfully and profitably. In other localities the injury done by this insect makes attempts to grow the tree almost impracticable. Black locust, like most forest trees, is naturally better adapted to certain types of soils and situations than others.

The vigor of the tree apparently to a great extent determines the degree of attack by the locust borer. Fortunately the tree's vigor can within limits largely be determined by man through the selection of the soil or site for planting, the method of planting, and subsequent care and cultivation.

Before attempting to plant black locust on a considerable scale, it would be advisable to secure information and advice from one or more of the local State forestry agencies, as a necessary supplement to that contained in this bulletin.

GROWING BLACK LOCUST TREES

By WILBUR R. MATTOON, *extension forester, Division of Private Forestry,
Forest Service*

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BLACK OR "YELLOW" LOCUST (*Robinia pseudoacacia* L.) makes rapid growth on good soils, grows moderately well on fairly poor and dry soils, is easily propagated, and produces very durable wood. It is a legume, and by virtue of its root nodules it enriches the soil. Its strong spreading root system and rapid development give it high rank among all trees in ability to check erosion in gullies and on steep hillsides. Its very durable wood makes it widely sought and used for fence posts, stakes, and poles.

The flowers are a source of large amounts of honey of good quality.

The increasing scarcity of chestnut for posts, poles, and stakes has done much to stimulate interest in the possibilities of growing black locusts for those uses. The expansion of the livestock business, including dairying, calls for greater numbers and better kinds of posts.

Many farmers would profit by planting a patch of black locust trees to supply fence posts.

The black locust has a dangerous insect enemy known as the black locust borer. The menace of this insect should be carefully considered before choosing black locust as a tree to plant. Accompanying shipments of young locust trees from the Eastern States, the locust borer has been introduced into many of the States of the Rocky Mountain region and is there becoming a serious pest. It is present almost everywhere that black locust is grown, except in some of the States of the extreme West.

In many localities, however, black locust is extensively grown with fair to good success and profit as the insects, although present, are not a serious pest. The recent extensive developments by State and Federal agencies in the checking of soil erosion have resulted

since 1933 in the greatest known era of growing and planting black locust seedlings.

The black locust was introduced into Europe more than a century ago and has been extensively planted and is greatly appreciated.

WHERE BLACK LOCUST GROWS

Black locust is found widely over the United States, especially in the eastern half. Its native or original home, however, was probably in the Appalachian Mountains, including the outlying piedmont, where it grew singly or in small groups among other hardwood trees.

Black locust is generally recommended for planting from southern New England through New York and Pennsylvania, south to Georgia, and west as far as Illinois, Missouri, and Texas. Limestone soils and the brown loams and other well-drained areas in the lowlands of the central Mississippi Valley are particularly favorable for its rapid growth. Black locust has spread over the Arkansas-Missouri-Oklahoma uplands. Under irrigation it is proving successful and valuable in many parts of the Western States.



FIGURE 1.—Growing alone in the open, black locust makes a well-shaped tree with branches that droop at the ends. It is handsome when in full bloom.

In certain regions the climate seems to be unfavorable for the growth of locust. For example, northern New England, and some of the lake States appear to be too cold for successful commercial plantations and most of the southern coastal plain too hot. Serious losses from the locust borer have been reported from various places in Pennsylvania, from the low country of the Ohio River Valley and other parts of Ohio and Kentucky, from parts of Indiana and of the Iowa-Missouri area. However, locust is successfully grown in various other places in these States, and the State forestry agencies of practically all of these States are recommending the planting of locust. The explanation seems to lie largely in the favorableness or unfavorableness of the soil.

Black locust is seldom found and should not be planted in very sandy, very dry, very poor, very acid, or poorly drained soils. It grows best on alkaline, nonacid, or moderately acid soils (fig. 1). In its ability to grow on well-drained locations, such as banks and hillsides, black locust ranks high among the native trees.

USES OF THE WOOD

The wood is heavy, hard, and very durable. For durability in the ground the wood ranks higher than that of all other native trees except Osage-orange or bois d'arc ("bow-dark"). It is extensively used for fence posts, the heartwood lasting from 15 to 30 years and sometimes more than 50 years. The heartwood of young trees, however, seems to be less durable than that of older trees, and it should always be well seasoned before being used. Locust is also used for grape stakes, poles, insulator pins, and treenails for shipbuilding. The trunk is nearly all heartwood, which is formed comparatively early in the life of the tree. It is good practice to peel the bark before using the wood for posts or poles (figs. 2 and 3).

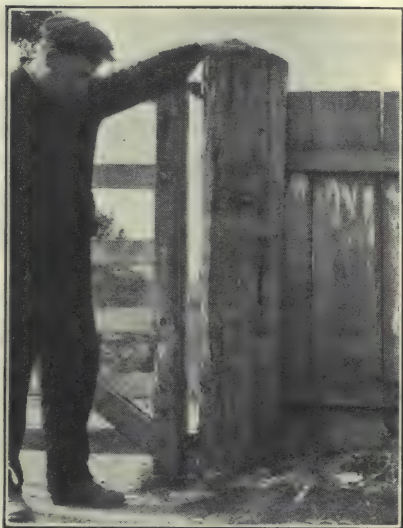


FIGURE 2.—Black locust wood is hard and exceptionally durable when in the ground. It makes the best fence posts. This 14-by 14-inch locust post was in good condition after 55 years of service.



FIGURE 3.—Black locust is in good demand for use in making fence posts, stakes, insulator pins, and treenails.

BLACK LOCUST FOR CHECKING EROSION

Black locust is widely recognized as a tree of exceptional value for checking soil erosion and washing and for that purpose has come to be used extensively in many regions. It is often seen growing naturally on steep banks along roadsides or railroad cuts and fills.

Often it is the only tree found in such places. It reproduces itself freely from root suckers as well as from stump sprouts.

The earliest extensive plantings for checking erosion are to be found in the brown of loessial silt loam soils over western Tennessee. Since 1914, in cooperation with landowners, the State forest service has assisted in the reforestation of several thousand acres. These landowners became demonstrators in stopping soil washing and gullying.

The approval in 1933 of an extensive Federal flood-control project in the central Mississippi River Basin by means of revegetating eroding lands started the planting of black locust on a vast scale (fig. 4). In the 3 following years about 250 million seedlings of black locust were planted for that purpose.

GROWTH

The rate of growth of black locust varies widely in different soils and climates in the United States, ranging all the way from extremely fast to very slow. Much depends also upon the spacing or tree density on the ground. Open-spaced trees grow more rapidly in diameter than closely grown trees. Where the soil and climate are favorable the growth should average from 2 to 4 feet in height a year and from one-quarter to one-half inch a year in diameter after the first few years.

Under such conditions it grows rapidly and yields fence posts in 10 to 20 years. In poor, very acid, or dense soils, including subsoils in borrow pits and on badly eroding slopes where locust often spreads naturally, growth is usually slow. Slightly acid soils seem favorable. In good soils, especially deep loamy soils, early growth is sometimes phenomenally rapid, up to 10 feet a year (fig. 5).

In well-spaced stands on average-quality soil within the region of fair to good growth, the trees may be expected at 15 years of age to reach average heights of 20 to 30 feet and diameters (outside the bark at breast height) of 3 to 5 inches; and at 20 years, diameters of 4 to 7 inches. In overcrowded stands or in poor locations the trees may be expected to be smaller, while in favorable situations they will usually be even larger.

In any situation black locust is a tree that reaches commercial maturity comparatively early; it should be cut usually before it is 25 to 30 years old. Under unfavorable conditions trees and stands after reaching an age of 15 to 20 years are often injured badly by insects and by heart rot diseases or fungi. Trees live for 40 or more years, in good soil and favorable regions, before showing signs of old age.

One of the essentials of good soil for growing locust is the presence of nitrifying bacteria, as indicated by the abundance of nodules on the roots. These bacteria seem to have a direct bearing on the growth and therefore the extent of attack by the locust borer. In places where the roots show relatively few nodules, the insect infestation is more serious than in places where the root nodules are abundant. Additional information about growth and insect attack is needed for different regions.

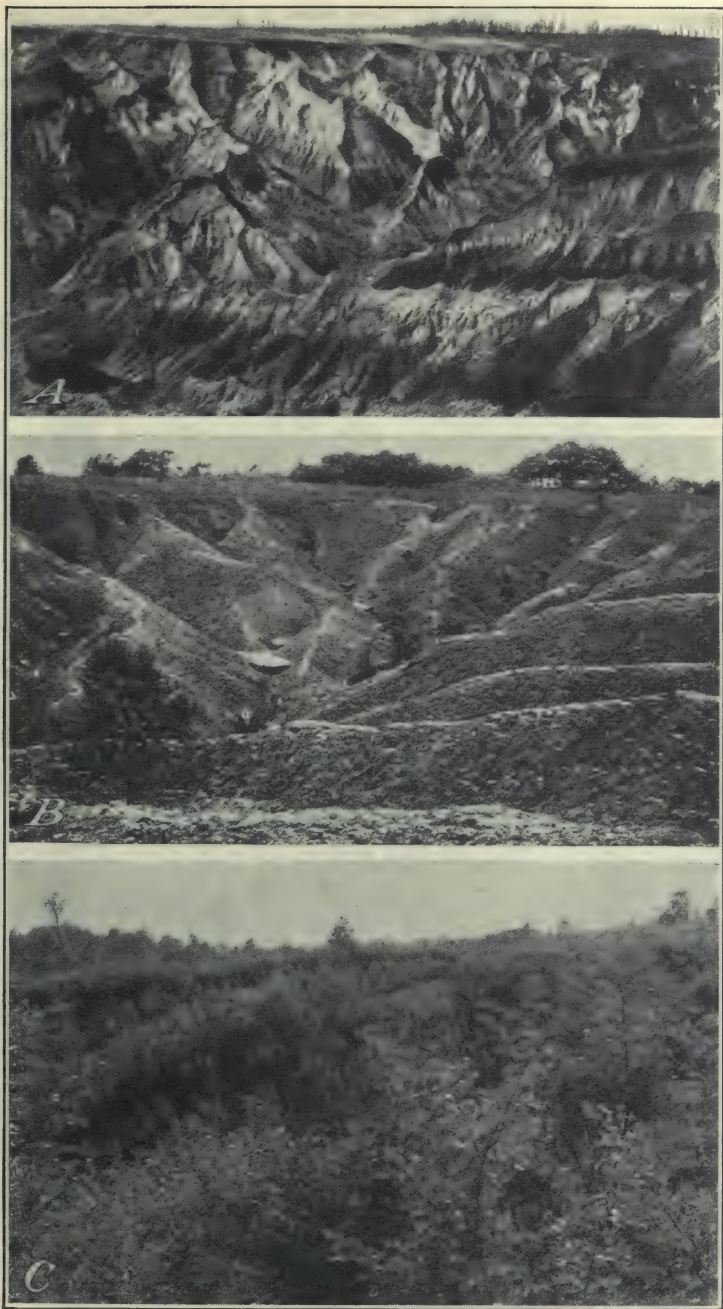


FIGURE 4.—The healing of the Borgsmiller farm gully in Jackson County, Ill., by black locust planted by the Civilian Conservation Corps under the direction of the Department of Agriculture: *A*, The gully before it was treated; *B*, the small check dams that were built and the banks that were sloped and planted with black locust seedlings—time, early spring; *C*, the gully completely reforested and producing a crop of timber—time, 1 year after *B* was taken.



FIGURE 5.—Maximum growth of black locust planted to heal a gully, 25 feet in height at end of second year. Martin County, Ind.

GROWING BLACK LOCUST SEEDLINGS

The planting of black locust is recommended on good soils within the favorable regions above described. For the purpose of checking erosion it may be planted on poorer soils. The planting of black locust involves a risk of some damage and, in some localities, of serious loss because of the locust borer. In this connection too much emphasis cannot be laid upon the desirability of getting the advice of the State forester, of the State forestry organization, or of the State extension forester who is connected with the agricultural extension service. By planting on good soils, by interplanting with other heavy-foliaged trees, or by moderate spacing and good cultivation, black locust can often be grown with fair to good success in insect-infested localities. The secret in any case apparently lies in stimulating rapid growth of the tree and in shading the tree trunks, thus creating unfavorable conditions for the borer, which more often attacks portions of the tree exposed to direct sunlight.

HOW TO GET SEED AND SEEDLINGS

The black locust produces good seed in abundance. It also sprouts vigorously after being cut or killed back by fire. Thus, it is easy both to start a tract of young trees and to get another generation of trees following cutting. Planting is most likely to succeed when done with 1-year-old seedlings grown from seed. Direct seeding of the land where trees are desired should not be attempted. The seeds do not germinate freely without attention.

Locust plantations have been started with wild or dugup sprouts, but the method usually requires considerable labor and is relatively slow and costly. However, it saves 1 year over the method of raising seedlings in nursery beds. It is an easy matter to sow the seed in a garden or nursery bed and after one season have a supply of vigorous seedlings ready for planting. If seedlings are not available for purchase at a fair price, growing one's own seedlings will be the most satisfactory method of obtaining a supply. The seeds are contained in small pods and should be collected from the trees in the fall and kept stored over a winter in a cool, dry place.

Many of the State departments of forestry sell seedlings at nominal cost for planting on farms or elsewhere (fig. 6). Some of the more recently established governmental agencies furnish seedlings for demonstration purposes. Prices commonly range from 50 cents to \$1 a pound for seed and from \$3 to \$5 a thousand for seedlings, depending largely on the size of the seedling as well as the order. Occasionally small lots of seed are furnished free by the State to adults or 4-H club members. Addresses of commercial dealers handling seed or seedlings can be obtained on request from various State forestry agencies or the Forest Service, United States Department of Agriculture.

COLLECTING AND CLEANING SEED

The seed of black locust ripens in pods in the early fall, and much of it often remains on the tree. The pods are collected preferably in the fall or early winter and during dry weather. Afterward

there is a continuing loss of seed from the pods. Hand picking from a stepladder or short ladder is a common method. If cutting of trees is in progress, the pods may be picked most easily. When dried, the pods may be opened by flailing, beating, or rubbing. In large operations seeds are most easily extracted by using a grain separator or threshing machine, suitably adjusted for the purpose. Beating a strong sack filled with dry pods with a flail or club is a good method for small quantities.

The cost of collecting and cleaning seed varies widely with the quantity and method used. Under fair conditions, on an average, a man may collect about 2 pounds of pods per hour, or 14 to 20 pounds per day, which should yield from 3 to 5 pounds of clean seed. Scant data are available on the cost of extracting and cleaning black locust seed, but in fair-sized operations it should not cost over 3 cents



FIGURE 6.—Nursery beds of 1-season-old black locust seedlings. Small trees ranging in height from 12 to 18 inches and having taproots shaped like long slender radishes are most desirable for planting. (This State nursery in western Tennessee contained about 20 million black locust seedlings.)

per bushel. When a small home-made thresher with a capacity of 50 pounds of dry pods per hour was used, the cost was about 4 cents per pound of seed.

A bushel of pods weighs from 7 to 14 pounds, averaging about 10 pounds. The seed yield from different lots of seed varies greatly, ranging from 2 to 5 pounds of clean seed per bushel of pods, probably averaging about 3 pounds. This is at the rate of a pound of clean seed from $3\frac{1}{2}$ pounds of pods. One quart of seed weighs from 1.4 to 1.8 pounds—or an average of 1.6 pounds. A pound of seed contains usually from 20,000 to 25,000, varying with the average size and density.

TREATING SEED TO AID GERMINATION

Black locust seed differs widely in its germination capacity. Sometimes only from 10 to 20 seeds out of every hundred germinate successfully; other lots of seed may have as many as 40 to 60 and occasionally 90. The average is low, perhaps from 30 to 40. The probable cause is the variation in hardness or density of the seed

coats and the consequently varying degree to which moisture, necessary for germination, passes through them.

Different treatments to increase germination have been worked out and tried, with varying results. (1) The one longest in use is the hot-water treatment. It consists of soaking the seed in warm water, starting at somewhat below the boiling point (about 160° F.), for 12 to 20 hours. (2) The chemical method is to treat the seed with sulphuric acid. (3) The mechanical treatment is to scarify, scratch, wear, or thin down the seed coats. Various means include agitating the seed in a revolving drum or other container in which it is mixed with sand or small gravel; shaking it in a sealed jar; tumbling it in some sort of a revolving hopper or drum in which baffle plates are fitted; or blowing it against a curved surface covered with a sharp sandpaper or garnet paper. This last method has given good results as it finely scratches the seed coats without cracking them and bringing about consequent loss of seed. There are various scarifying machines on the market designed for treating clover and other agricultural seed which, with simple modifications, can be successfully used for black locust seed.

The hot-water treatment is easy to apply and is known to hasten germination in many lots of seed, but in many others is ineffective because of the very hard and impermeable seed coats. The acid treatment requires much care in handling, including length of treatment. When rightly applied, it markedly aids germination, but at the same time causes losses of young seedlings under warm, wet soil conditions. The best combined results of germination and of hardiness of the resulting young seedlings have apparently been obtained when the seed was scarified. Much probably will be learned by means of further experiments. It might be advisable to treat a portion of the seed by one or more of the methods and observe the results as compared with sowing the seed without any special treatment.

Directions for treating black locust seed, if desired, will be furnished upon request if application is made to the regional forester, United States Forest Service, at Washington, D. C., at Atlanta, Ga., or at Milwaukee, Wis.

GROWING SEEDLINGS IN NURSERY

A good quality of agricultural soil, such as a deep sandy loam, should be chosen for the nursery site. Apparently a slightly acid soil gives the most favorable development of locust seedlings and at the same time freedom from disease (soils with a pH of about 5.00+).

It is essential to prepare the soil thoroughly in readiness for seed sowing and to mark out beds 4½ feet in width, with paths 18 or 24 inches in width. A farmer may not need more than a single bed. Generally, a bed 4½ feet in width by 25 feet in length (100 square feet of seeded bed) sown in drills 6 inches apart will require about one-third pound of seed and may be expected to produce from 800 to 1,500 or an average of 1,200 good or no. 1 locust seedlings.

Early spring is a favorable time for seed sowing in order to take advantage of the better soil moisture—an important requirement for good germination. One method is to sow seed in drills 4 feet

long, spaced 6 inches apart and running across the bed, to allow for hoe cultivation. The seeds may be sown about one-fourth inch apart with the expectation of obtaining germination and growth sufficient to get good seedlings every 2 inches apart. This would give an average of about 1,200 no. 1 seedlings on every 100 square feet of planted area, or allowing for beds $4\frac{1}{2}$ feet in width, a gross area of $112\frac{1}{2}$ square feet.

The seeds may be covered one-fourth inch in depth, preferably with a sandy loam soil which will not crust or bake in the sun after rains. A fundamental requirement is good moisture and warmth during the germination period, which in warm spring weather may be 10 to 14 days. To maintain such conditions a light mulch of clean straw, pine straw, or leaf litter is often desirable.

Much depends upon the weather conditions, which are normally variable from year to year as well as day to day. One method is to wait until late spring or early summer (June), sow the seed in beds that are well-soaked by rain or watering, cover the seed lightly with sifted soil, then mulch with straw or leaf litter to maintain good heat and moisture conditions. As soon as the seed begin to germinate it is very necessary to remove most of the mulch. This method of late sowing is often used where watering equipment is available to force the growth during dry spells. Otherwise the spring sowing is often best to take advantage of the spring moisture. Heavy watering during the season is usually inadvisable because it results in too large seedlings. A desirable size of seedling is from 12 to 18 inches in height. However, excellent results have followed with small trees averaging some less than 12 inches in height. In any event, a prime factor for good planting stock is a medium top and well-developed taproot like a long radish in shape. All seedlings with slender taproots may be regarded as culls, particularly if the tops are over 8 to 12 inches in length. If seedlings are 3 feet or more, they can be set with or without cutting back the tops. One-year-old seedlings are universally used, as 2-year stock is practically always too large to handle economically.

LARGE-SCALE PRODUCTION

An acre divided into beds 100 feet long and $4\frac{1}{2}$ feet in width and separated by 18-inch paths, will have about 70 beds with an aggregate of 28,000 square feet of seeded bed. At the rate of 1,200 trees per 100 square feet of seeded bed there should be approximately 336,000 per acre. If there are only 8 seedlings instead of 12 per square foot, as may often happen, the production will be about 224,000 per acre. The common maximum is probably about 500,000, and the average probably about 300,000 per acre.

CARE OF NURSERY BEDS

The growing seedlings should be kept clean of weeds and given occasional cultivation. Except in the case of a real drought, it should not be necessary to water the beds. Medium-dry conditions will tend to develop desirable plants with small tops and large root systems. Any excess of rain or watering may result in too large stock, say from $2\frac{1}{2}$ to 5 feet in height. Black locust withstands fairly dry conditions very well.

PLANTING BLACK LOCUST SEEDLINGS

A FEW ESSENTIALS FOR SUCCESS

It may be well to mention a few of the essentials for success in planting, as far as known at the present time. Future research and observation will undoubtedly add to what is now known.

A prime essential for success in planting black locust seedlings is to break up or prepare the ground well. Pines may be set in firm soil; but to be successful, locust should be set in ground that has been well broken and worked to make a good plant bed. In such ground the lateral roots will find easy entrance and stimulate good top development. If planted in a small hole in hard though fertile soil, the locust may barely live for a year or more but seldom makes a normal growth.

The best time for planting or setting locust seedlings is in early spring before the buds begin to swell. If set out late in the spring after leafing starts, the seedlings should be cut back nearly to the ground. In loose soils locusts may be planted in the fall after good rains have wet the ground to a considerable depth. Fall planting is dangerous in all tight soils because of probable injury from frost heaving.

Seedlings with small spindling or threadlike taproots, or culls, probably come from undersized or weak seeds and even in good soil will not make satisfactory growth.

In planting, the seedling and particularly the roots should be kept moist at all times. Sometimes the planter drops the trees far ahead of the setting, and the tree dries; this may not kill the seedling but injures its vitality and chances of good growth.

If seedlings are to be held over or stored after digging they should be heeled in. The soil should be packed well around the root and lower stems and the ground kept moist. Heeled-in trees should be well shaded. Damage from root disease has been found in such storage in the South.

PREPARING THE GROUND FOR PLANTING

In advance of planting, the soil should be well prepared. Many failures or near failures can be traced directly to planting locust seedlings in hard ground. In abandoned fields it will usually not be difficult or costly to break the ground and disk or harrow it. Then it should be laid off in furrows with the desired spacing. If it is not practical to break all the ground by plowing, a good planting bed should be prepared by plowing at least two furrows running in the same direction. A better planting bed is made by running a middlebuster or lister plow and afterward throwing a furrow inward from each side (fig. 7). Successive planting beds should be made every 6 feet apart or other desired spacing.

In planting gullies, the best method is to plow down the banks beginning at the top. The next-best preparation is to plow a couple of furrows along a contour to make a planting bed in the form of a low terrace. This is repeated each 5 or 6 feet to the bottom. It is essential to plow down the gully edges in order to reduce the gradient and throw topsoil into the gully bottoms to aid the vegetative growth. In large or deep gullies it is essential first to build a series of low check dams across the gully bottom at selected points



FIGURE 7.—Preparing the soil for planting black locust: *A*, Plowed land is best; *B*, plowing contour furrows 6 feet apart on slopes; *C*, bedding the soil by three to six furrows.

to catch and hold the soil later to be plowed off the edges and sides. All of the preparation requires work, but it is well worth the effort as it secures the desired results in holding the soil until the trees become well established.

To be effective, check dams in gullies must be carefully made. For brush dams use scrubby or low-grade trees or brush and cut the limbs and trunks into lengths of 4 feet or more, depending upon the width of the gully. Place these across the gully. Bind them by adding some long branches lengthwise of the gully, with the tops upstream. Build a compact structure and weight it down with heavy tree-trunk sections or with rocks. If necessary, drive stakes through the brush and limbs to secure the dam in time of flood. All dams should be low, often 18 inches but not to exceed 2 feet in height



FIGURE 8.—Before planting black locust or other vegetation to heal large gullies, it is essential to build low check dams to help hold the soil until the trees become well established.

(Fig. 8). The best time to make dams is in the summer, when the trees are in leaf. Dams built in the summer or fall should get a good catch of soil in which to set locust seedlings the following spring. Trees or other growth near gullies should not be cut, as their living roots and tops will be of much value in binding the soil and checking surface erosion. Other types of check dams are built of stone, logs, or other material, often with heavy chicken wire and grass, straw, or light tree tops. The dams, except those of stone, are temporary, and it is expected that they will be replaced by dams of living trees, grass, or vines.

DIGGING, STORING, AND TRANSPORTING SEEDLINGS

The aim should emphatically be to get the trees planted with the least possible delay after they are removed from the nursery bed. The digging, or lifting, and all subsequent handling of locust planting stock require special care. The soil about the roots should be

loosened with a spade, in small operations, or with a plow or special digging machine if the nursery is more extensive. The tops and larger roots should not be bruised or otherwise injured. It is almost always necessary to prune the taproots in addition to the slight pruning or breaking of the roots inevitable in the process of digging. Ten inches in length is about the maximum for taproots. It is important to sort and roughly grade the seedlings as follows: (1) Culls, to be discarded all of those with spindling or threadlike taproots; (2) usable seedlings divided into at least two groups, according to size. The seedlings should be tied into bundles of 50 or 100 each.

The bundles of trees should be transported so far as possible directly from the nursery to the planting site and there planted. Sometimes they must be held in readiness for planting later. This means that they must be heeled in at or near the nursery or the planting grounds. The essentials of heeling in are: (1) Selecting a cool and moist but well-drained place; (2) digging a trench with a sloping side piling all soil on the opposite side; (3) laying the bundles (opened by cutting the cord and spreading open the seedlings) consecutively in the trench against the sloping side and covering the roots and base of stems with soil well-packed, to exclude excess air; (4) watering the seedlings well, if the soil is not moist do not let the soil become dry at any time; (5) providing shade for the heeled-in beds during early fall or late spring when the sun is warm and the air often dry. This may consist of brush laid on elevated racks or stringers or clean grain straw loosely piled over the beds. A cellar or cool storage will keep the trees in good condition.

TRANSPORTATION

The essentials are to keep the trees moist and cool and to prevent mechanical injury. The small tree bundles may be made up in packages of 500 to 1,000 trees each, wrapped with burlap or heavy paper and tied. Wooden boxes or crates are often used for holding bundles of small trees. The greatest danger usually comes from the drying or the heating of the tops and roots, with resulting death or reduction in vitality of the trees.

SPACING THE TREES

The distance apart, and, therefore, the number of trees to be planted per acre, depends mainly upon the purpose of planting, upon topography, and upon soil conditions. A rather common spacing for tree production is 6 by 6 feet apart each way (Fig. 9). On eroding lands of gentle slope this should be a good spacing, but on steep slopes and gully banks where a soil binder is needed quickly a spacing of 5 by 5 feet, or occasionally a minimum of 4 by 4 feet, is desirable. These successive spacings require 1,210, 1,743, and 2,723 trees, respectively, per acre. The richer and moister the soil within certain limits the more rapidly the trees grow and the sooner their roots and their tops meet. Likewise on poorer or drier soil the opposite is generally true, and more trees per unit of area are usually planted.

PLANTING OR SETTING THE SEEDLINGS

The small trees are set much like cabbage or tomato plants. They should be set with the least possible delay after they are removed



FIGURE 9.—Worn-out farm field of about 6 acres planted with black locust 6 feet apart each way. Carlisle County, Ky. The trees are 25 to 35 feet in height at 8 years of age and making straight, valuable post timber.

from the nursery bed. It is of prime importance to keep the roots moist at all times and to set the trees firmly in the ground, with their roots spread out and not curled upward or bunched. Young black locusts set in cultivated or prepared ground usually grow well even if the fertility of the soil is low. Likewise, if they are set in small pockets in hard though good soil, the growth will be unsatisfactory (fig. 10). An impervious hardpan near the surface is practically fatal to their growth or survival.

The seedlings may be carried in buckets having water and should never be dropped ahead of setting. A crew of two men is often employed, one digging the holes and the other setting the trees. The tools most commonly used are a mattock or a light grub hoe. The number of the crew is varied, depending on the ease of planting; one



FIGURE 10.—Because the hard ground was not first broken up by plowing to make a loose planting bed, the results were poor. The trees were carried about in buckets containing water and carefully set in holes dug with a mattock. Because the roots could not expand rapidly the trees were stunted, and many died during dry periods.

digger may prepare the ground for two or more setters, or in hard ground it may be necessary for two men to dig the requisite large, well-cultivated holes or spots while one man sets the trees. Planting is done by holding the tree in a normal position while carefully drawing in the soil around and over the roots. The soil should always be well firmed with the foot about the tree, and preferably some loose litter should be spread over the surface as a mulch.

In loose soil the slit method of planting is very often used. It consists of making a wedge-shaped opening with a mattock, spade, or dibble, in which the tree is held and the soil pressed and firmed. The latter tool consists of a narrow, flat iron blade and extended handle. Although not usually as good a method for getting the roots well placed, this is a rapid and often a satisfactory method.

The best method of preparing gully banks for planting is to plow the banks on the contour, solid if possible, otherwise open a single

or a double furrow in which to plant the trees. On smooth gully banks, the "pocket" method should be used. An ample pocket or shelf

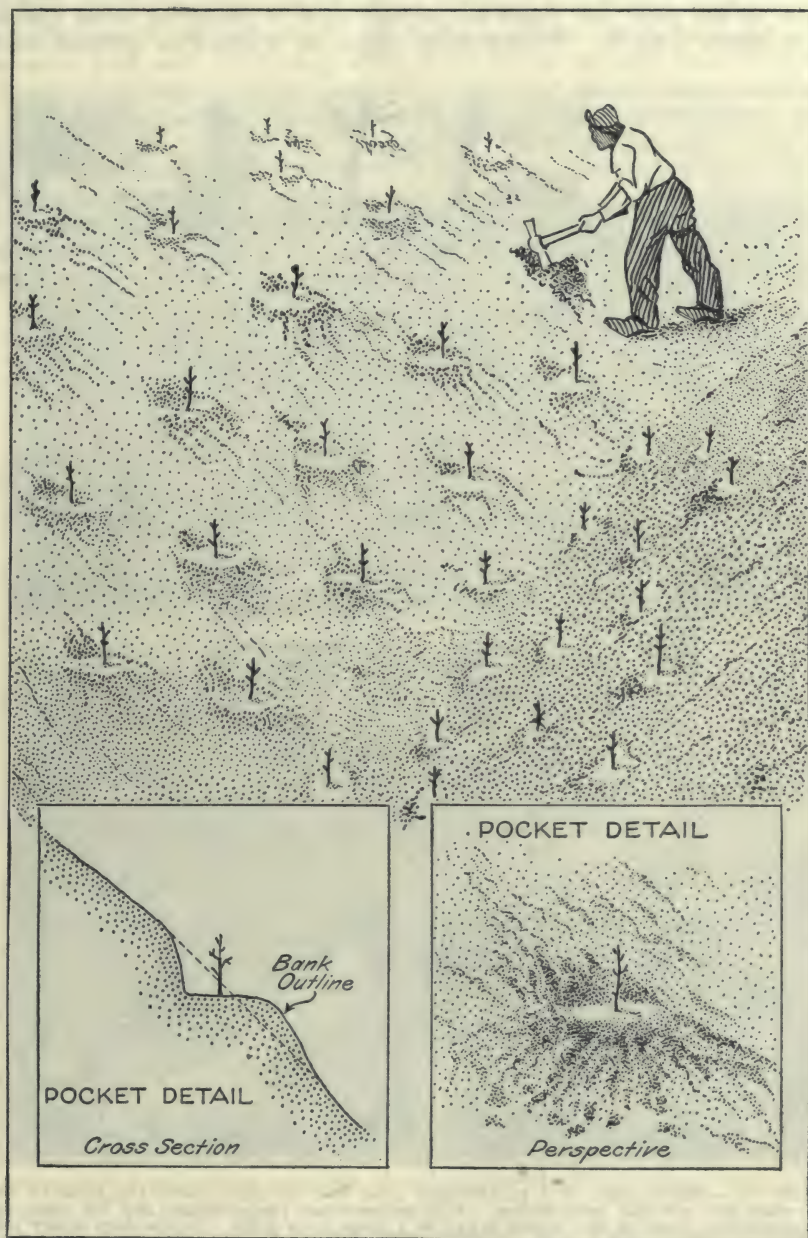


FIGURE 11.—The pocket method of planting seedlings is recommended for use on steep slopes if the trees are not set in contour furrows. Pockets, niches, or shelves catch run-off and retard soil washing.

is dug in the bank in which the tree is to be set, as shown in figure 11. This is effective in helping to check rapid water run-off and thus improve soil-moisture conditions. Soil erosion is also lessened.

PURE OR MIXED PLANTING

Black locust may be planted alone in pure stands, as has been largely done in the past, but there are advantages in planting other species in mixture with it. Where steep slopes or washed or gullied lands

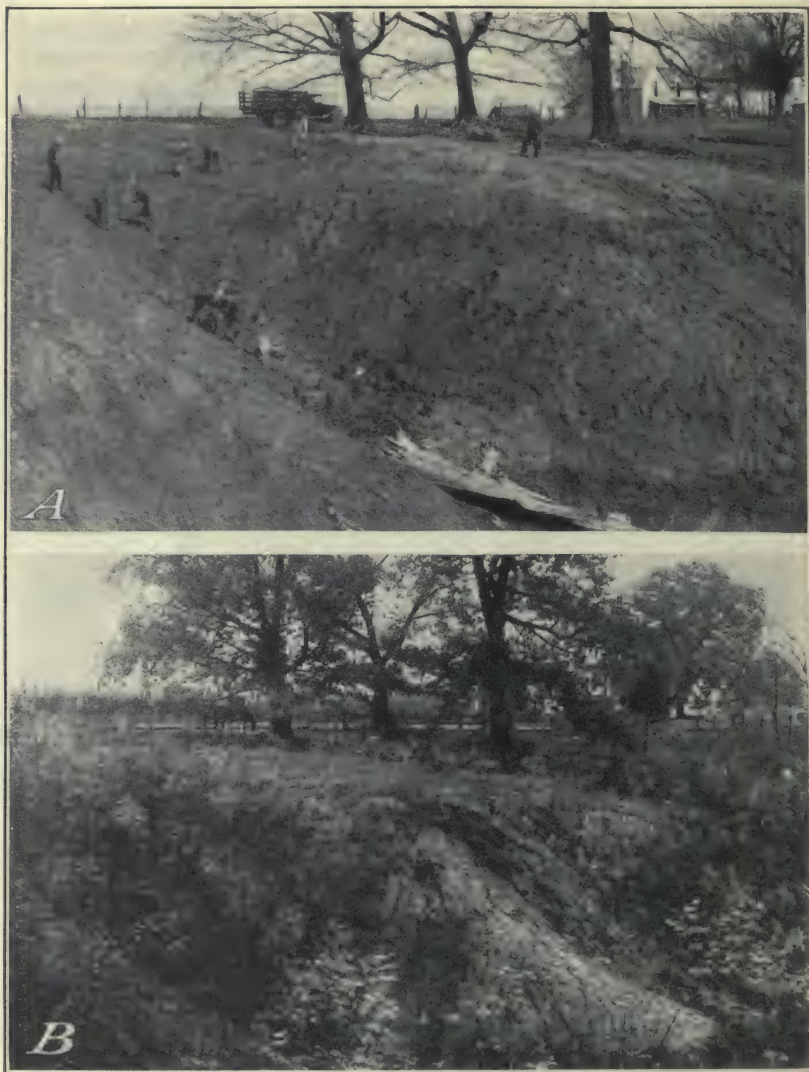


FIGURE 12.—Black locust is a particularly good tree to plant about the farm to stop erosion and put idle land to use. *A*, Planting black locust, white and red oaks, and honeysuckle vines on the sloped banks of a large farm gully. In the deep richer soils black walnut and yellow poplar (tuliptree) were planted. *B*, Appearance of the banks at the end of one season that happened to be abnormally dry. Gibson County, Tenn.

are in need of a quick cover to check erosion, it may be well to plant locust pure.

The purpose of adding other trees, shrubs, or vines is to get a heavier protective shade and bed of litter over the ground. This

favors more rapid growth, which in turn reduces the menace of the black locust borer and twig borer. Black locust is a sun-loving tree which produces only a light shade, offering insufficient shade for retaining good soil moisture. In regions where the borers are not a serious pest and in good-quality soils where growth will likely be rapid, plantings of locust alone will often give satisfactory results.

The filler trees of other species may be planted alternately in each row or solidly in alternate rows or otherwise (fig. 12). Various kinds of trees are suggested as filler trees for different regions. However, as there are few experimental data on the subject, the suggestions are largely based upon general observations. In the northeastern or cooler portion of the black locust range, red oak, sugar maple, and white ash might be planted. Farther south the trees might in-



FIGURE 13.—Pines planted in pure stands on the dry ridges and black locust on the slopes of a deep gully in the central Mississippi Valley. The two kinds should not be interplanted.

clude southern red oak, on the better soils yellow poplar (tuliptree) and white ash, and on the best or agricultural soils black walnut. On the drier and poorer soils, the black oak may be considered because it is relatively hardy, although the timber product is of low grade. In connection with planting black locust, some conifers should be considered for planting pure in small blocks or patches because they will grow well on relatively dry and sterile soils not adapted to black locust. On such local areas or portions, the red, white, and jack pines may be planted in pure stands in the northeastern region, and in the middle South shortleaf and loblolly pines. There appear to be good grounds for advising against closely interplanting pines with black locust. The results appear to be poor whenever this is done. The pines should, therefore, be planted pure in small or larger blocks on the drier ridges or areas and the locust in the better soils (fig. 13). Red cedar is a very hardy tree on dry and low-grade soils; except in districts of commercial apple production, it should be used quite extensively as a filler tree, either alternately or in pure stands locally on unfavorable soils in the black locust plantation.

Natural or volunteer trees of various local species may be expected to come into black locust stands. Because of the open, light shade such stands act as a good "nurse" and favor trees that start from seeds blown in or dropped there by birds or animals.

SHIPMAST LOCUST

Among the varieties of black locust the so-called shipmast locust is important because of the straightness of its trunk, its good rate of growth, and the good quality of wood (fig. 14). The main stem or trunk is excurrent, like that of pines and yellow poplar. It is found chiefly on Long Island, N. Y., where it is thought to have been introduced about 2 centuries ago from some unknown point in Virginia. Only rarely does it produce seed, and these are mostly infertile; thus shipmast locust is reproduced only vegetatively, by means of root cuttings (4 to 5 inches in length) and sprouts. (See Department of Agriculture Circ. No. 379, Shipmast Locust.)

INJURIOUS INSECTS¹

LOCUST BORER

The adult locust borer (*Cyllene robiniae*) is a handsome beetle, about one-half inch in length, black with yellow stripes, and with long horns or antennae. It is most frequently seen in late summer or early fall, feeding on the pollen of goldenrod. The borer is found in practically all parts of the United States where black locust is growing.

The injury is caused by the feeding of the larva or grub in the sapwood and heartwood of the trunk and of the larger branches. It makes large burrows which weaken the tree and sometimes result in its death by wind or heavy girdling. The eggs, which are laid in bark crevices, hatch into larvae or grubs that live over winter hidden in the inner bark. In the spring these larvae begin to burrow actively and feed vigorously on the wood of the tree until they pupate in July or August. The presence of the young borer is easily detected in the early spring. Pellets, damp or wet from the oozing sap, will be seen coming out of holes, mostly in the tree trunk where the bark is rough. Old attacks may be recognized by calloused swellings on the trunk or large branches.

Means of reducing borer attack on trees in forest plantations and method of control for use on individual dooryard trees are discussed on pages 22 to 25.

LOCUST TWIG BORER

In its larval stages the locust twig borer (*Ecdytolopha insitiana*), a moth insect, causes considerable damage by eating and boring in the young, tender growing twigs in the earlier part of the growing season. It is not known that it attacks any other part of the tree or at any other season. There are two generations a year, and the winter season is passed in the pupal stages in the ground. Adult moths of the first generation appear about May or June and those of the second generation in August or September.

¹ Acknowledgment is made of the information on the locust borer, locust twig borer, and leaf miner, and helpful measures for their control furnished by Ralph C. Hall, assistant entomologist, Bureau of Entomology and Plant Quarantine, associated with the Central States Forest Experiment Station at Columbus, Ohio.

The injury to the succulent twigs often seriously slows up the current season's growth and deforms the stem. The twig borer is the chief cause of insect damage to young stock growing in nurseries,



FIGURE 14.—Shipmast locust is a variety of black locust so named because of the unusual straightness of its single upright trunk. These trees, growing in Centerport, Long Island, N. Y., at the age of 65 years, average 95 feet in height and range up to 18 inches in diameter.

and also during the first few years after the trees are planted out. Some degree of control is possible in small nurseries or plantations by cutting and burning the infested twigs near the end of the first and middle of the second period of active injury, namely, in late June and early September.

LOCUST LEAF MINER

In midsummer or early fall the foliage of black locust trees often turns from its usual light green to a grayish brown. A close examination will show little left but the veins or skeletons of the leaves. The green portion, or chlorenchyma, has been eaten by an insect known as a locust leaf miner. The most common species in the Eastern States is a sawfly (*Odontota dorsalis*) but there are known to be one or more closely related insects that mine the green in the leaves. The effect is to retard the growth of the tree slightly, but nothing more serious. It is not practicable to attempt to check the insect.

CARE AND CULTIVATION

TREATMENT HELPFUL IN REDUCING INSECT ATTACK

In addition to the usual care needed by trees planted for timber production or windbreaks there are some points in handling black locust that are effective in reducing the attack and injury of harmful insects, particularly the locust borer.

Important practices in the care of young stands, that will pay well, all center around keeping the growth thrifty and vigorous. For reducing the borer attack the following practices are to be recommended:

(1) Choose favorable soils or locations for planting black locust. This is most important in localities of bad borer infestation but should always be kept in mind.

(2) Prepare the soil thoroughly so as to make a good planting bed in which it will be easy for the lateral roots to spread rapidly. Often, fair to good success has been attained by planting locust in poor or sterile soil that was well plowed or disked in advance of planting. There are insufficient data on which to base any general recommendations for adding fertilizer to the soil at the time of planting. However, experiments in adding a teaspoonful of commercial fertilizer, containing nitrogen, phosphoric acid, and potash, have shown decidedly good results in stimulated vigor during the first 2 years. The cost per acre has been reported as not more than 60 cents. Some soils require only acid phosphate.

(3) Cultivate the planted tract well for at least the first season after planting. It would be better to continue cultivation during the second year. If this is not practicable, weeding and cultivation around each tree will prove very beneficial. A mulch of straw, leaves or other vegetable matter around the tree will help in holding needed moisture and keeping the soil loose. In the Great Plains cultivation is very essential and should be kept up for a much longer period.

(4) Increase the protective ground cover to maintain vigorous growth of the trees. The black locust makes only a light shade and a thin leaf litter over the surface of the ground. Therefore the soil dries and hardens, becoming unfavorable to good rates of growth. It is therefore very desirable to interplant locusts with other trees that have heavy foliage and that are also slower growing so as not to overtop the locusts. After the young trees reach a height of 8

feet or so everything should be done to encourage volunteer growth. Weeds and low vines often afford such a desirable ground cover. The Japanese honeysuckle vine is often seen growing with black locust trees and almost always affording a beneficial ground cover. Contrary to a misconception, it rarely harms a tree by getting into the foliage. This vine is a very weak climber and should be clearly differentiated from the wild grape and kudzu, both of which are lusty climbers and commonly smother and kill trees.

(5) Provide shade for the tree trunks, if practicable. A dense growth of locust growing in deep, fertile soil well supplied with moisture, or locust trees with trunks shaded by slower growing heavy-foliaged species of trees as a rule are found to be thriftier and less subject to infestation.

(6) Protect young black locust from all grazing by livestock. It is a legume and palatable at all times of the year, and subject to heavy browsing, particularly in the dormant season, when green foliage is absent. Cattle and horses, as well as sheep and goats, browse freely on the locust twigs and branches and often break down young trees. It is also very essential to preserve a complete ground cover of vegetation and humus over the ground. By trampling, grazing and browsing, livestock quickly break up the protective cover, and the ground becomes hard and dry. This condition is very unfavorable to vigorous tree growth.

(7) Keep out fire at all times. The reason is obvious, and it should be noted specially that black locust is particularly susceptible to injury and death by burning. Young locust has a very thin bark, and the roots are shallow. Any removal of the vegetative cover from the soil will immediately be shown by its effect upon the vigor and life of locust trees, even if the fire is so light as not to cause direct injury.

Closely related is the effect of severe drought in lessening the vitality of black locust trees to a point where the borer readily overcomes the weakened resistance of the trees and severely injures or kills them.

(8) Prune back stagnated stands. As black locust is a vigorously sprouting species, it is good practice to cut clean slow-growing, stunted young trees up to 3 to 6 years of age. If this is done, preferably in the dormant season, the result should be vigorous sprouts that will be much freer of insect attack. The colonies of sprouts should be reduced to a single tree; midsummer is the best time for the cutting, as sprouting is then least vigorous.

Pruning early is a very important aid in producing a straight clean trunk. In midsummer of the second growing season after planting the one straightest and strongest central stem should be freed to grow singly by cutting off all other competing or framework stems. It is a great mistake to cut off the many weak laterals that will never compete as a central stem but are valuable in supporting the foliage and therefore furnish food for the growth of the main trunk. Vigorous growing trees might well be shaped by pruning in the first season, and conversely slow developing trees might not need pruning until their third year. Early and repeated

pruning is to be favored and will pay well in developing straight post or pole timber. A second pruning will usually be required from 1 to 3 years after the first pruning. The character of growth will determine whether later pruning becomes necessary.

Overpruning should be avoided, as severe cutting almost stops the growth of the tree. The leaves are virtually the food factor of the tree. In them is manufactured all of the substance out of which wood is made. Pruning should be done in midsummer, as there is then the least opportunity for successful sprouting.



FIGURE 15.—Stand of black locust thinned out to favor rapid growth of each tree.

(9) Thin out the less vigorous trees in black locust stands (fig. 15). They are most susceptible to infestation and often become breeding trees for insects. The survival of larvae in the spring is least on the dominant and more vigorous trees and highest on stunted trees. Quite similarly, old, overmature locust trees are dangerous breeding places; therefore, if any occur near young stands they should be cut and used.

(10) No practicable method of direct control of the locust borer is known that can be applied to large-scale or forest plantations of black locust. However, treatment for killing or controlling the borer on individual trees of special value, such as those planted on lawns or streets, may be practicable. An effective method is to spray the trunks, especially the lower parts up to 8 feet in height, with crude orthodichlorobenzene solution. This should be prepared in the following proportion: 1 gallon of orthodichlorobenzene, 1 gallon of soft water, and 1 pound of fish-oil soap or common laundry soap. The soap is dissolved in boiling water and after the mixture has been well cooled, the orthodichlorobenzene is added, and the whole stirred well. To make up the spray solution, add about 4 parts of

soft water and stir well. Early spring, about the time the young leaves begin to unfold, is the best period for applying the spray.

PRODUCTION OF TIMBER

CUTTING THE TREES

The trees should be cut during the period from late fall to late winter, in order to promote vigorous sprouting the following spring. The sprouts which grow following midsummer cutting do not usually become sufficiently hardened to withstand the winter freezings. It is also important to cut stumps low, only a few inches above the ground.



FIGURE 16.—Fifteen-year-old black locust plantation in Cayuga County (near Ithaca), N. Y. The smaller trees are marked for cutting, which will leave a stand of trees at the rate of 322 per acre. The plantation is regarded as very successful.

It is only the heartwood of black locust that is extremely durable in contact with soil. The sapwood decays more rapidly. It is usually very narrow, consisting of only the last three or four rings of new wood. For use as posts or poles, therefore, trees should preferably not be cut at such an early age or in such small sizes that a considerable portion of the wood is sapwood. By the time the tree is 6 to 8 inches in diameter on the stump it usually has enough heartwood to warrant cutting. Such trees commonly can be grown in about 12 to 15 years where soil and climate are favorable (fig. 16) or in 20 years in less favorable places. Smaller and younger

trees when cut in making thinnings to improve the growth of the stand will of course become available for use.

There is a widespread habit of allowing black locust trees to grow beyond their age of maturity, which is often 20 to 30 years. Such trees develop heart decay (fig. 17). This applies more particularly to trees grown in open stands about the farm, rather than to forest-grown trees.

The trees from the second growth or sprout crop, will grow faster and can be harvested at least 5 years sooner than those of the original seedling crop. They are usually less subject to insect attack than trees of seedling origin. To cut the crop of trees would often prove a good means of renewing badly infested stands of black locust.

Occasionally a land-owner objects to putting black locust on his place because he has heard that it is difficult to get rid of it. A sure and simple way to do this is to cut all the locust trees preferably in the spring and turn cattle, sheep, or goats on the land. They will browse the sprouts and kill out all the locusts.

POSTS FROM BLACK LOCUST TREES

The number and size of fence posts that may be cut from black locust trees of different sizes are often of interest. Obviously the cut from a tree depends



FIGURE 17.—Black locust trees grow rapidly and mature at earlier ages than most forest trees. Old trees are commonly infected with the borer and some fungus diseases. Such old trees are often preserved about the home because of their flowers.

upon its height, diameter, and the straightness and soundness of its trunk. In other words, it depends upon the tree's merchantable length, diameter, and soundness.

For example, a black locust tree of regular shape, measuring 8 inches in diameter (outside the bark at $4\frac{1}{2}$ feet above the ground) and 50 feet in height, as shown in table 1, will on an average cut out seven round or equivalent split posts, each 7 feet in length. Of these, four will be 4-inch posts (top diameter inside the bark), two

5-inch posts, and one a 6-inch post. By way of comparison, a tree of the same diameter (8 inches) but 60 feet in height can be cut into nine posts, of which five will be 4-inch, three 5-inch, and one a 6-inch post in top diameter. The posts will be round or split and of equivalent bulk.

TABLE 1.—Number of 7-foot fence posts that can be cut from black locust trees of different heights and diameters and of average straightness and soundness ¹

Diameter of tree outside bark at height of 4½ feet (inches)	Total height of tree	Posts (round or equivalent split posts) from average-shaped tree			
		4-inch ²	5-inch ²	6-inch ²	Total per tree
	Feet	Number	Number	Number	Number ³
6.....	30	1			1
	40	1			1
	50	2			2
	60	2			2
	70	3	1		3
7.....	40	2	1		3
	50	3	1		4
	60	3	2		5
	70	4	2		6
	80	3	1		4
8.....	40	4	2	1	7
	50	4	2	1	7
	60	5	3	1	9
	70	6	4	1	11
	80	5	3	1	9
9.....	50	6	3	2	11
	60	8	4	2	14
	70	10	5	3	18
	80	11	6	3	20
	90	6	4	2	12
10.....	50	8	5	2	15
	60	11	6	3	20
	70	13	7	4	24
	80	16	9	5	30
	90	7	5	2	14
11.....	50	10	6	3	19
	60	13	7	4	24
	70	17	9	5	31
	80	20	11	6	37
	90	23	13	7	43
12.....	40	9	6	3	18
	50	12	7	4	23
	60	16	9	5	30
	70	20	11	6	37
	80	24	14	7	45
13.....	90	28	16	9	53
	60	20	12	7	39
	70	24	14	8	46
	80	28	17	9	54
	90	32	20	11	63
14.....	60	23	14	8	45
	70	28	17	10	55
	80	33	20	12	65
	90	38	24	13	75
	60	26	16	10	52
15.....	70	32	20	12	64
	80	39	25	14	78
	90	30	19	11	60
	70	37	23	14	74
	80	45	28	17	90
16.....	60	33	22	13	68
	70	42	26	17	85
	80	52	32	20	104
	90	38	25	15	78
	70	48	30	19	97
17.....	80	58	36	23	117
	70	54	33	22	109
	80	66	40	26	132
	90	60	37	25	122
	70	73	44	29	146

¹ Computed by the Central States Forest Experiment Station (U. S. Forest Service). The values are calculated and have not been checked by actual cutting operations.

² Measured inside bark.

³ The sums of the 3 previous columns.

The production of posts from trees up to 20 inches in diameter can be found in table 1. The assumption is that the trees are sound and comparatively straight; therefore, in using the table necessary deductions should be made for defect or deformity.

The number of split posts that can be cut from round posts, bolts or billets is shown in table 2. For example, a round stick measuring 10 inches (inside the bark at the small end) will split out six 4-inch posts, or four 5-inch, or two 6-inch split posts.

PROFITS

It is doubtful whether as large net money profits per acre have been derived in periods of 10 to 20 years from the growing of any other forest-tree species as those that are known definitely to have accrued from the growing of black locust. These are mostly from \$5 to \$10 an acre yearly but range up to more than \$20 (figs. 18 and 19).

TABLE 2.—*Number of split posts of specific diameters or sizes that can be derived from round posts¹ of different diameters*

Diameter of split posts (inches)	4-inch	5-inch	6-inch	7-inch	8-inch	9-inch	10-inch	11-inch	12-inch	13-inch	14-inch	15-inch	16-inch	17-inch	18-inch	19-inch
	No. 1	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 10	No. 12	No. 14	No. 16	No. 18	No. 20	No. 22
4-----	1	1	2	3	4	5	6	7	8	10	12	14	16	18	20	22
5-----		1	1	2	2	3	4	5	5	6	8	9	10	11	13	14
6-----			1	1	1	2	2	3	4	4	5	6	7	8	9	10

¹ Measured inside the bark at the small end.

NOTE.—The numbers are complete as they stand. For example, a 10-inch round post will split out 6, 4-inch split posts, or 4 5-inch split posts, or 2, 6-inch split posts.

Compiled by the Central States Forest Experiment Station, U. S. Forest Service.

All these examples are taken from stands grown in good soils or in regions naturally favorable to the trees. On the other hand, cases of utter failure occur, although confined mostly to instances where the trees were grown under conditions or in regions known to be generally unfavorable. For example, in parts of Pennsylvania, West Virginia, Kentucky, and Indiana which are generally supposed to be in the favorable range of black locust, there have been conflicting reports regarding the success and profit in growing black locust.

FURTHER INFORMATION

In considering the question of planting land to black locust trees or growing them, it is very advisable to consult your State forestry department, your agricultural extension service, your agricultural county agent, who is the local representative of the State college of agriculture, or the Forest Service, United States Department of Agriculture. These agencies are in a position to offer advice and give to the States assistance in securing tree seeds or seedlings.



FIGURE 18.—This 20-year-old black locust grove was started by planting year-old seedlings on a worn-out and gullying field. It contains 1,880 posts per acre, worth 10 cents in the tree, or \$188 per acre. This is an average yearly gross income of \$8.40 per acre.

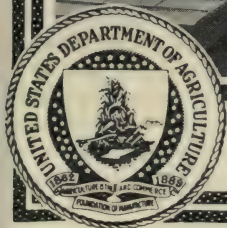


FIGURE 19.—A valuable stand of tall straight black locust trees, age 27 years from time of planting, Bartholomew County, Ind. The trees range up to 14 inches breast-high diameter and 80 feet in height. Many of the trees will cut from 30 to 50 fence posts each, and a few 60 to 65 posts.

U. S. DEPARTMENT OF
AGRICULTURE

FARMERS' BULLETIN No. 1629

**STEAM
STERILIZATION
OF SOIL
FOR TOBACCO
AND OTHER CROPS**



U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF PLANT INDUSTRY

SOIL STERILIZATION is being generally adopted for the production of tobacco and other seedlings in plant beds and for the culture of certain plants in glass houses. The inverted steam-pan method is the most common and satisfactory method of performing this operation in out-of-door seedbeds.

The marked benefits secured from soil sterilization are due largely to the destruction of plant diseases, insects, and weed seeds harbored in the soil and to the increased soil fertility which usually accompanies the treatment.

This bulletin describes the equipment necessary for soil sterilization by the steam-pan and other methods. Advice is also given relative to the details of preparing the soil, performing the work, and the subsequent management of the sterilized soil. Modifications to suit special needs and requirements are also suggested.

This bulletin supersedes Farmers' Bulletin 996, Steam Sterilization of Seed Beds for Tobacco and Other Crops.

Washington, D. C.

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STEAM STERILIZATION OF SOIL FOR TOBACCO AND OTHER CROPS ¹

By JAMES JOHNSON, *agent, Division of Tobacco and Plant Nutrition, Bureau of Plant Industry, and professor of horticulture, College of Agriculture, University of Wisconsin*

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INTRODUCTION

THE PRODUCTION of early, vigorous, and healthy seedling plants of tobacco and other crops is one of the most important steps in their successful cultivation. The sterilization of soil by steam is of great aid in the production of desirable plants. The practice of soil sterilization has become very general in recent years in tobacco and in vegetable forcing-house districts, though the idea is by no means a new one. The beneficial effects of heated soils on plant growth were recognized by the ancients, and methods of burning over the surface soil for certain crops have been practiced for centuries. With the modern development of agriculture on a more intensive scale and along more scientific lines, new and definite reasons for soil sterilization became evident, and, consequently, improved methods of sterilization have been sought. Various types of heat and chemical treatments for this purpose have been tested, but as yet none has proved as efficient and reliable as sterilization by steam.

The principal purposes of soil sterilization are concerned with the destruction of soil-borne plant diseases, weed seeds, and in some cases soil-hibernating insects, and at the same time sterilization ordinarily has the effect of increasing soil fertility and producing conditions in general more favorable to the rate and uniformity of plant growth.

While the beneficial action of steam sterilization on plant growth is usually very striking, it should be more generally understood that a temporary injurious effect on seed germination and early plant growth usually precedes the beneficial effect. It is also important to remember that improper sterilization and poor management of the

¹ Additional information on soil sterilization is given in U. S. Department of Agriculture Technical Bulletin 443.

soil after treatment may yield unsatisfactory results. When good judgment is used in applying the treatment, steam sterilization will be found to be an increasingly profitable practice for the culture of tobacco and vegetables, as well as for numerous other plants.

EFFECTS OF STERILIZING THE SOIL

SOIL-BORNE DISEASES DESTROYED

A large number of the most injurious diseases of plants are harbored in the soil. Some of these diseases are particularly destructive to germinating seeds and young seedlings. Others may cause little or no actual injury in the seedbed, merely infecting the plant in the seedling stage but producing damage in the field later in the season or in following seasons as a result of the dissemination of the pest throughout the fields during transplanting.

The following diseases of tobacco may be wholly or partially harbored in or on the soil: Damping-off or bed rot, black root rot, root

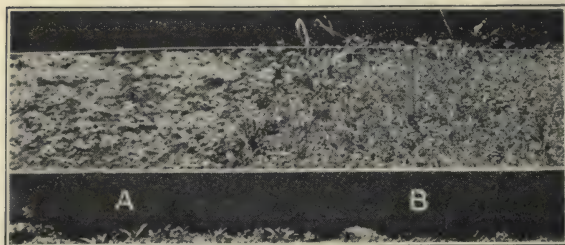


FIGURE 1.—One of the most conspicuous advantages of steam sterilization of soil is the destruction of weed seeds: A, Steam sterilized tobacco seed bed; B, not sterilized.

knot, black shank, sore shin, mosaic, wildfire, and black fire. In addition, brown root rot, a malady of uncertain nature but associated with the effect of preceding crops grown on the land, may be obviated by steam treatment of the soil.

Similar soil-borne diseases affect vari-

ous other seedlings from those of orchids to forest trees. The only available method for the destruction of the bacteria, fungi, or other infectious disease-producing agencies carried in the soil is sterilization of the soil by means of heat or chemicals. Some of these diseases, however, may be avoided by a change of soil or by the use of disease-resistant varieties, but even in such cases soil sterilization for other purposes is desirable.

SOIL-HIBERNATING INSECTS AND OTHER PESTS DESTROYED

Insects and other forms of animal life living or being harbored in the soil in certain stages of their life are, of course, killed by the steaming of the soil.

For the control of pests which may migrate to the seedbeds from other locations after the steaming has been performed, such as springtails, flea beetles, grubs, aphids, the red spider, and slugs, consult the Bureau of Entomology of this Department or write for farmers' bulletins relating to the control of tobacco pests.

DESTRUCTION OF WEED SEEDS

Most plant growers who have used the steaming method find that it pays from the weed-killing standpoint alone (fig. 1). The weeding by hand of even comparatively small seedbed areas is fre-

quently tedious and expensive, coming as it does during the spring rush of work, whereas the destruction of weed seeds by steaming is rapid and efficient. In order to kill all the weed seeds, however, the steaming must be properly done. If the soil is steamed when too compact or moist, or for too short a time, many of the weed seeds may escape. This is especially true of certain seeds such as clover, which are somewhat resistant to heat as compared with other seeds.

INCREASE IN SOIL FERTILITY

A common beneficial effect of steaming the soil is the increased rate of plant growth eventually obtained. This is largely on account of the increased fertility of the soil brought about by conversion of unavailable forms of nitrogen into available forms as a result of the heat and of changes in the type of soil organisms predominating, of which some are injurious and others are beneficial to the liberation of plant food. In soils naturally low in plant-food elements, especially in very sandy soils, steaming may be of little or no benefit in this respect.

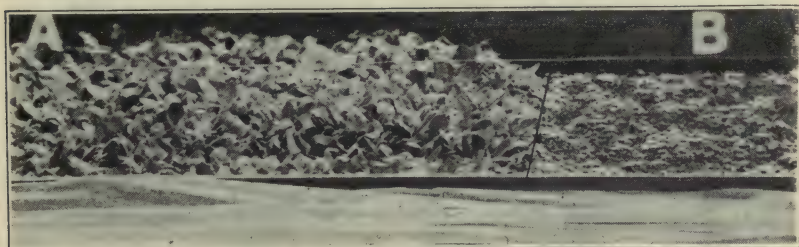


FIGURE 2.—Stimulating effect of steaming the soil on growth of tobacco seedlings: A, Tobacco on steam-sterilized soil; B, tobacco on unsterilized soil.

The increase in growth of plants on certain steamed soils is often remarkable (fig. 2). Steamed soil may frequently produce early, vigorous, and uniform tobacco plants, while unsteamed soil immediately adjoining may fail completely to produce satisfactory plants in time for transplanting.

INJURIOUS EFFECTS OF SOIL STERILIZATION

Temporary retardation of seed germination and of early plant growth is characteristic of heat-sterilized soil as compared with unsterilized soil. This effect may last such a short time as to be hardly noticeable or may be manifest for some weeks. The plants ordinarily recover rapidly, however, and the beneficial effects of the steaming soon overcome the early setback. The temporary toxic effect appears to develop as a consequence of an overproduction of ammonia in the soil. When the ammonia becomes absorbed or changed to nitrates, it serves as a plant food, resulting in an increased rate of growth of the plants. The amount of injurious and beneficial action on plant growth varies with the soil type, the temperature of heating, the length of heating, the species of plant grown in the soil, and other factors. With our present knowledge of the subject, it is impossible to predict the extent of the injurious or beneficial action that is likely to result in any particular soil.

Another type of injurious action in steamed soils is that due to disturbed water relations. For some time after steaming, the soil may not take up or hold water readily. Consequently, steamed soils dry out rapidly, with resulting danger to very young seedlings if not watered judiciously during dry, hot weather. This condition is also temporary and is more marked in some soils than others. Naturally, these temporary injurious effects may be largely overcome by steaming some time prior to seeding or planting.

METHODS OF STERILIZING SOIL

There are two principal ways in which soil may be sterilized, namely, by heat and by chemicals.

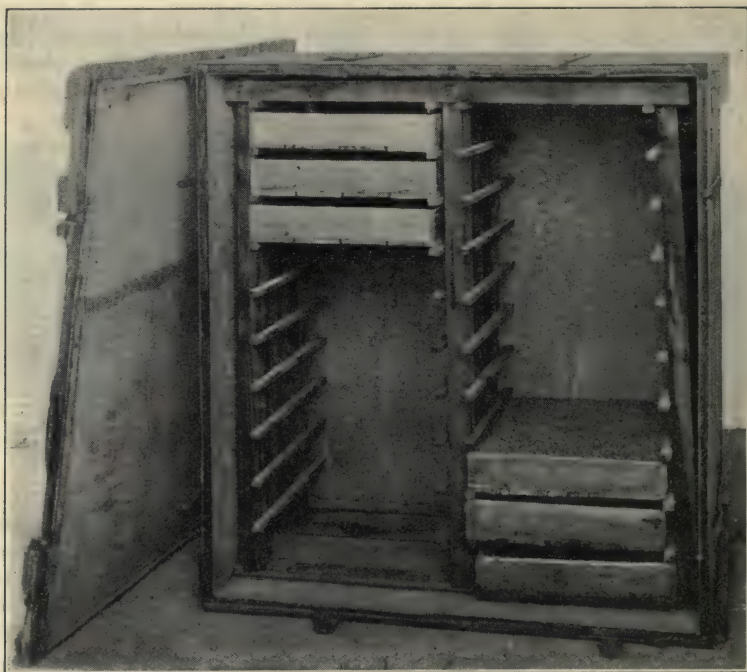


FIGURE 3.—Device for steaming soil in greenhouse flats. When only small quantities of soil are to be sterilized, a simple chamber of this sort may be constructed cheaply.

Various methods of sterilization by heat have been developed and practiced at different times. The old surface-firing method consists simply in burning brush or logs on the ground to be sown and depends largely for its sterilizing action on the conversion of the soil moisture to hot water or steam. If it is carried too far the soil may be "burned" and certain of its physical and chemical properties injured. The first modification of this method was essentially a roasting process, the soil being placed on supported sheet iron and a fire placed below. A patented tobacco plant-bed furnace for more convenient roasting of the soil may be secured on the market. Both the surface-firing and the roasting methods are used to a considerable extent in southern tobacco-growing sections, especially where wood is plentiful and steam boilers are scarce.

Boiler-generated steam was first used to sterilize soil for greenhouse seedlings by installing a perforated steam pipe in a box in which the soil was placed for heating. With various types of improvement in the construction of the sterilizing box or chamber, this method is frequently used in greenhouse practice (fig. 3). For sterilizing large quantities of greenhouse bed soil with less handling, horizontal grids of perforated pipe or tile systems are buried about 8 to 12 inches below the soil surface, for the uniform distribution of steam in the soil. Still another modification of this principle is the harrow type of sterilizer in which short vertical perforated pipes set on a grid of steam pipes are forced into the soil from the surface. This involves still less handling of the soil than in the case of the

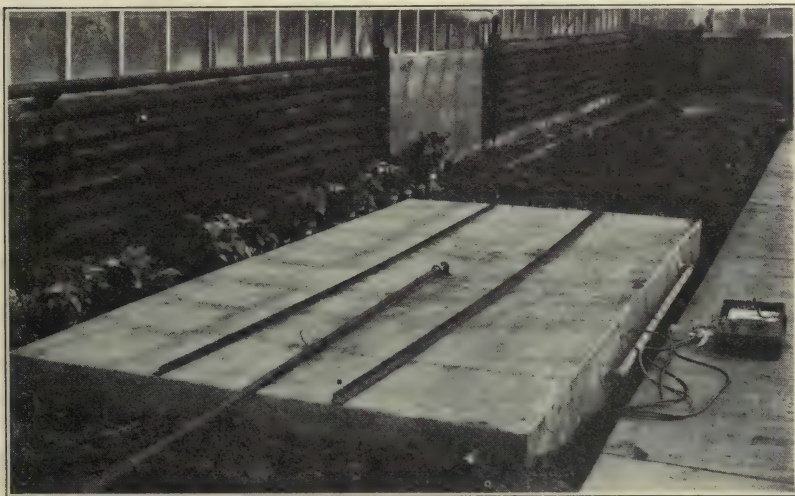


FIGURE 4.—The inverted pan used for steaming the soil. The instrument shown to the right was being used experimentally for the measurement of the temperature of the soil at various depths during and following steaming.

removable perforated-pipe system. Neither the perforated pipe nor the harrow system has come into general use on account of certain disadvantages. The permanent tile system has some advantages in greenhouse-soil sterilization and is being tested outdoors.

The big improvement in methods of sterilization came with the development of the inverted steam-pan method, which possesses many advantages in convenience and efficiency over the earlier methods, especially for out-of-door seedbeds. In principle this procedure consists simply in placing a large pan over the soil in an inverted position and running steam under the pan, thus confining the steam near the soil surface and forcing it into the soil beneath (fig. 4). This is the method now generally recommended for tobacco growers and widely used by them for seedbed sterilization. It is also frequently used in the production of other seedlings and for greenhouse vegetable culture.

Another method of heat treatment of soil that has received some consideration in recent years is sterilization by the use of hot water. This method may be useful in special instances, but so far as known it has not been practical except on a small scale.

A great deal of investigational work has been carried on in an attempt to find a suitable chemical for soil-sterilization purposes. Several difficulties lie in the way of much progress in this direction, and until a cheap, rapidly volatilizing chemical is found which can be applied to the soil in the dry state and which is as efficient as heat in sterilization, it is not probable that the latter will be displaced.

Of the large number of substances tried, formaldehyde is the only one that has been frequently used. The cost of its use is, however, about as great as that of steaming and the results are usually less satisfactory. Drenching the soil with formalin at the rate of 1 part to 50 parts of water is useful in certain instances where the control of fungus infestation of the soil is of major importance. The formaldehyde-dust method is a modification of this treatment. Acetic acid, copper, and zinc compounds have proved successful for disinfection in some instances.

THE INVERTED-PAN METHOD OF STEAMING THE SOIL

EQUIPMENT NECESSARY

Since the steam-pan method is the most practical one for the steam sterilization of soil for tobacco seedbeds, it is the only one that will be discussed in detail in this bulletin.

A suitable steam boiler, steaming pan, and connecting steam hose or pipe of proper size and convenient length (as shown on the title-page of this bulletin) are required for the sterilization of soil by this method. The steam boiler is the most important and most expensive item of equipment. Where only a small area of soil is to be sterilized, as is usually the case with seedbeds, individual growers cannot economically purchase or maintain a boiler for this purpose alone. Consequently, it is the usual practice for persons owning portable boilers for other purposes to supply themselves with the remainder of the necessary equipment for soil steaming and to perform this work for the growers in the community at an agreed price for a given area. In grain-growing regions suitable steam boilers used in threshing outfits are usually available for this purpose, but with the increasing tendency to use oil and gas power a scarcity of steam boilers is evident in certain regions. This is especially true in seasons in which weather conditions are unfavorable for steaming and the time available for the work is consequently short. It seems likely, therefore, that in the near future a moderately priced special boiler, mounted on a suitable truck, will need to be developed to replace the steam tractors now in use (fig. 5). Other smaller and more easily portable steam generators (propelled by gas motors) are also being developed for this purpose. Sterilization of soil in green-houses is usually simplified in this respect in that the steam-heating plant may be used, but even in this case boilers of sufficient capacity and capable of carrying a sufficient pressure must be available.

The boiler must in the first place be of sufficient capacity to supply the required quantity of steam for the size of pan used. In general, the greater the steam capacity of the boiler the larger the area that can be steamed at one time. A boiler of at least 20-horsepower capacity is necessary for a steam pan 72 square feet in area. A 30

or 40 horsepower boiler is usually even more desirable for this size of pan, since the desired steam pressure is more readily maintained.

The steam pressure in the boiler should be maintained above 80 pounds during steaming in order to furnish the required quantity of dry steam through a given-sized outlet into the pan. The actual pressure in the pan will in any case be only a fraction of a pound, but dry steam reduced the rate of waterlogging and consequently favors penetration of steam into the soil. In general, four factors are to be considered in planning the equipment, namely, the capacity of the boiler, the pressure that can be maintained, the size of the steam outlet (pipe or hose), and the size of the pan. The efficiency of the outfit will depend upon its ability to supply a continuous flow of high-temperature steam to the pan at a sufficient rate to heat the enclosed soil to about 212° F. to the greatest depth in the shortest

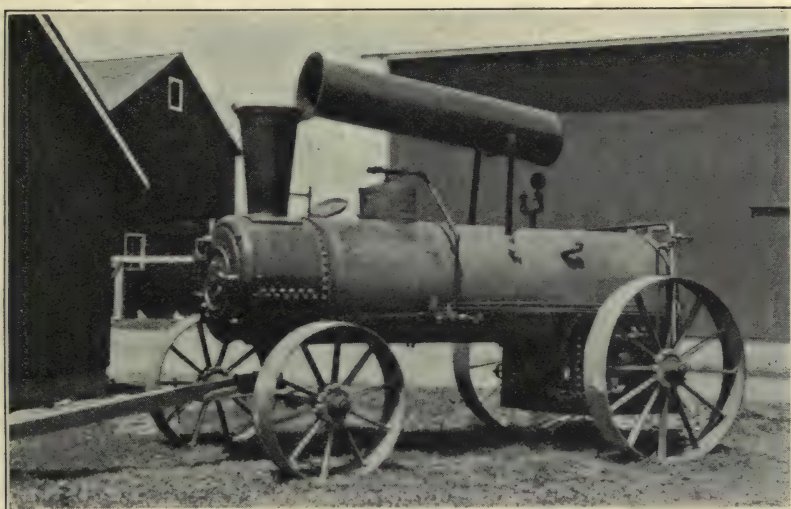


FIGURE 5.—Portable type of boiler adapted to the inverted-pan method of steaming.

possible length of time. Temperatures as low as 140° F. at greater depths will also have a sterilizing value. With a 40-horsepower boiler and a pressure maintained at 125 to 150 pounds together with a $\frac{3}{4}$ -inch hose connection, it is possible to supply a pan as large as 100 square feet with the necessary steam for efficient sterilization.

The steaming pan is preferably made of no. 16 galvanized iron, reinforced with angle iron, although pans made largely of lumber may be used in some cases at a smaller initial cost. The size, shape, and construction of the pan may be made to suit the particular conditions at hand. The pan may ordinarily vary from 50 to 100 square feet in area, 6 by 12 feet by 8 to 10 inches in height being common dimensions, although pans 14 and 16 feet long and 6 feet wide are sometimes used. For loose, sandy soils, a pan 10 inches deep is preferable. Handles of iron pipe, or other devices for carrying, are ordinarily attached. Many operators are now suspending the pan under a pair of wheels with a lifting device which enables it to be raised

readily and moved by one or two men. (Fig. 6.) The lower edge of the pan should be sharp so that it may be pressed readily into the soil, thereby reducing the escape of steam at the point of contact with the soil. The inlet for the steam may be made through the top or side of the pan but should be so placed that the steam is not thrown directly into the soil. Usually some sort of perforated pipe or cap distributor for the steam is desirable on the inside of the pan. It is usually preferable to have the steam pan constructed by sheet-metal shops equipped for such work.

The steam may be led from the boiler to the pan by means of pipe or steam hose or both, depending upon the distance from the pan to the boiler. Usually the boiler can be moved to the side of the area to be steamed and a 25-foot 4-ply steam hose will be found to be sufficient and most convenient.

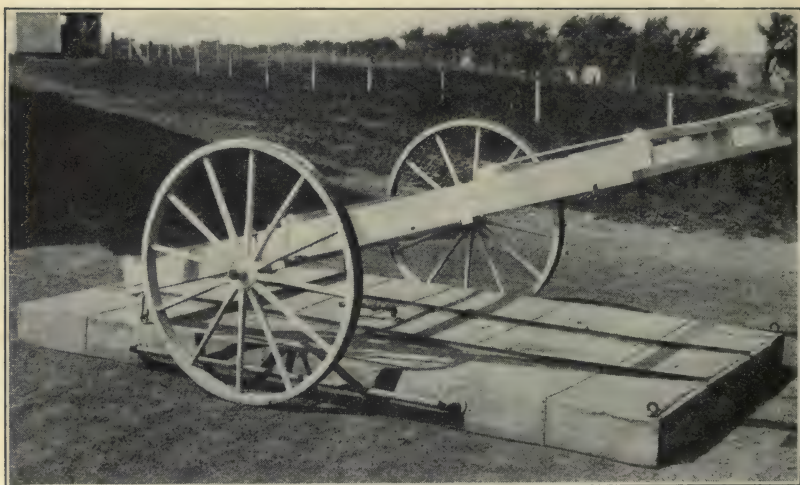


FIGURE 6.—Device for facilitating the moving of the steaming pans. The labor of soil sterilization may be reduced by hanging the heavy pan on a truck, as shown here, so that the pan can be easily moved and readily raised or lowered over the soil.

In addition to this equipment, growers in some sections prefer to carry sufficient heavy canvas or burlap to cover two or three pan areas of steamed soil after the removal of the pan, to conserve the heat in the soil for a longer period. It is even better to operate with two steaming pans, one of which is left in place on the freshly sterilized area to retain the heat while the other pan is used in steaming the next area.

PREPARATION OF THE SOIL FOR STEAMING

Steaming is usually performed a short time before the seed is to be sown. In some respects, however, it is preferable to steam soil two to three weeks before sowing seed, since this permits of a partial or complete recovery of the soil from the effects injurious to seed germination and early plant growth. On the other hand, if the soil is steamed months before use, some of the beneficial effects may be lost unless special precautions are taken. On account of certain advan-

tages, fall steaming for spring seedbeds may often be a desirable practice.

In the northern tobacco-growing sections it is the usual practice to begin steaming in the spring as soon as the condition of the soil and the weather permit. This means that the frost must be out of the ground and the soil sufficiently dry to be properly worked and prepared for a seedbed. It is poor policy to work or steam soil that is too wet. Five times as much heat is required to raise the temperature of a pound of water a given number of degrees as is required for the same weight of soil. Furthermore, steam cannot penetrate readily through wet soil, and the distribution of heat becomes dependent upon conduction, with resulting lowered efficiency in the entire operation. It is also important that the soil should not be too dry when steamed, since weed seeds and parasites are less readily killed in a dry, dormant state. The soil also takes up water less readily after being heated in a dry condition. There is little or no danger of the soil being too dry in out-of-door seedbeds in the spring of the year.

Where glass-covered seedbeds are to be used, the preparation of the soil for steaming may be advanced in the spring and the soil maintained in a suitable condition by placing the frames and sash in position on the area to be steamed.

Any animal manures to be used, of course, should be applied and the soil put into condition for sowing or planting by spading or by plowing and disking before applying the steaming process. The object of this final preparation is to reduce to a minimum the danger of losing certain of the benefits derived from sterilization through subsequent contamination by working the soil after steaming. Commercial fertilizers free from tobacco material may be safely applied to the soil and worked in to a depth of 2 inches after sterilization. The seedbed areas should be properly located and slightly raised above the surrounding ground to reduce the danger of flooding from heavy rains. If the seedbed frames are not permanent, they should be placed around the steamed areas as soon as convenient to aid in preventing contamination of the soil by weed seeds and plant parasites from outside. Every precaution should be taken to prevent the transfer of parasites to the seedbed in soil or on equipment moved from farm to farm as, for example, on the wheels of steam tractors.

FALL STEAMING

On account of the difficulty of performing the steaming sufficiently early in the spring during late or wet seasons, it seems advisable in many instances to resort to fall steaming. Most farmers would also find fall steaming preferable in that it would relieve the spring rush of work. While there are some disadvantages in fall steaming, particularly in the increased danger of recontamination of the soil with weed seeds and plant parasites, these may often be counterbalanced by several advantages. With a little additional care and expense, the danger of serious contamination of the soil may be partly prevented by choosing a desirable location for the beds and by protecting the soil with the frames and improvised covers of various sorts, such as old burlap or building paper.

The advantages of fall steaming naturally lie in reducing the rush of spring work and permitting earlier sowing than might otherwise be possible. There is considerable evidence that, on many soils, fall steaming well done and properly cared for will yield nearly as good results as spring steaming, even when the seed is sown at the same date. The preparation of the soil for fall steaming should be similar to that for spring steaming. Especial care should be taken, however, to prevent excessive flooding by locating the seedbeds desirably and providing adequate surrounding surface drainage. The soil should not be worked to any greater depth than necessary in preparing for sowing in the spring, loosening the soil to a depth of 3 or 4 inches usually being sufficient.

TIME REQUIRED FOR STEAMING

The time required to sterilize the soil thoroughly by the steam-pan method and at the same time to get the maximum benefit in increased plant growth naturally varies to some extent with the type and condition of the soil as well as with the efficiency of the equipment. The time required for efficient sterilization varies especially with the porosity, heat conductivity, and moisture-holding capacity of the soil. The tendency in recent years has been to cut down the time of steaming to periods as short as 15 or 20 minutes, regardless of conditions, but this often has led to very unsatisfactory results. Under average conditions fully 30 minutes are required for best results, and under poor conditions 35 to 40 minutes may be necessary to sterilize the soil effectively. Under unusually good conditions 20 to 25 minutes may suffice, but it is not advisable to reduce the steaming period to this length of time unless a trial on the same soil in the previous season has shown it to be adequate. It is possible to reduce the required time somewhat by the use of two pans alternately, as previously suggested, hence eliminating the necessity of moving a pan immediately after shutting off the steam. It is also possible to retain some heat by covering the soil with heavy canvas or burlap after the removal of the pan.

In this connection it may be stated that soil may be unnecessarily injured by heating for an excessive length of time. This may happen particularly in greenhouse soils where steaming is sometimes continued for hours.

TEMPERATURE

The temperature of the surface soil beneath the pan rises rapidly during steaming to approximately 210° to 212° F., the temperature of boiling water. As the steam comes in contact with the cool soil it rapidly condenses to water until the soil itself reaches the boiling temperature of water, when condensation is reduced to a minimum. If the surface inch or two becomes water-logged before reaching this temperature on account of steaming soils that are too wet at the start, the downward penetration of steam vapor is naturally interfered with, and the heating of the lower layers of soil becomes largely dependent upon heat conduction. Soil is a very poor conductor of heat, and as a consequence it requires considerable time to

heat layers of soil at a depth of 6 to 12 inches. On the other hand, the poor heat conductivity of soil reduces the rate of cooling after removal of the pan, and as a consequence considerable downward conduction of heat and sterilizing action may continue in the lower layers for several hours after the removal of the sterilizing pan. The rate of cooling is usually slowest at a depth of about 6 inches after 30 minutes of steaming. Sufficient heat may be maintained at this depth for 10 to 12 hours after steaming to have considerable sterilizing value. Sterilizing temperatures for soil steaming are ordinarily regarded as lying between 140° and 212° . These temperatures kill most weed seeds and soil organisms in a very few minutes, but the object of continued steaming is to secure these temperatures at as low a depth as possible.

MANAGEMENT OF STEAM-STERILIZED SEEDBEDS

If the seedbed frames are not already in position during sterilization, they should be placed as soon as possible after steaming, to reduce the danger of blowing or washing of unsterilized soil into the steamed area. Care should also be taken not to walk on the sterilized soil or to introduce disease infection or weed seeds in any other way. The soil should be prepared before steaming so as to require a minimum of working after steaming to prepare it for the seed.

The seedbed may be safely sown 12 hours after steaming, as far as soil temperature is concerned. Most soils are more or less toxic to seed germination and plant growth for some days after heating, and this injurious effect gradually diminishes as time elapses if the soil is in a moist condition. If the soil can be sterilized 1 or 2 weeks prior to sowing, therefore, a certain advantage is gained with respect to the rate of subsequent plant growth.

Since steamed soils usually dry out more rapidly and consequently may require more watering than unsteamed soils, it is well to give considerable attention to supplying water at the proper time in dry seasons when the seedlings are very young; otherwise small, tender seedlings like tobacco may be killed and the stand of plants in the seedbeds much reduced. This is particularly true with respect to glass-covered seedbeds and such beds as are sown with sprouted seed.

COST OF STEAMING

The cost of sterilizing tobacco-bed soil by the steam-pan method naturally varies considerably with the particular circumstances under which it is performed. Growers who do not have a steam boiler must rely upon having a steaming performed by contractors who operate steaming outfits. The charges may be at a given rate per square foot, per pan, or at a flat daily or hourly rate, the grower generally furnishing the necessary fuel, which is usually computed at one-half ton of soft coal for 1,000 square feet of seedbed area. The cost of steaming may be expected to vary from \$1 to \$2 per hundred square feet. On account of the shortness of the season for sterilization of seedbeds and the possible occurrence of unfavorable weather conditions, the work is usually speeded up by operating 24 hours daily.

While the cost of steaming may appear relatively high in some instances, it is necessary to consider in this connection the saving in cost of weeding and the benefits that may accrue from the production of early, healthy, and vigorous plants for transplanting.

SOIL STEAMING FOR CROPS OTHER THAN TOBACCO

The previous discussion has referred principally to the application of soil sterilization to tobacco culture. Manifestly, the same or similar methods may be applied to the production of other plant seedlings that are started in seedbeds and subsequently transplanted. The vegetable or truck gardener will, therefore, find the use of almost identical methods suitable for the production of the early, tender plants in particular, especially where seedbed diseases and weeds are abundant. Florists, nurserymen, and growers of special crops, such as ginseng, may also find the method adaptable to their problems. It is in the forcing of winter vegetables under glass, however, that soil sterilization has been most generally adopted. The culture of lettuce, radishes, tomatoes, and cucumbers in particular on a large scale under glasshouse conditions is accompanied by many difficulties not generally encountered in field crops. Since the soil is not exposed to the effects of winter and may be almost continuously under cultivation, it may become heavily infested with plant parasites of various kinds, especially nematodes and damping-off fungi. Soil sterilization by the steam method is the most practical remedy for these maladies, and in addition, the treatment generally hastens plant growth, this result being of especial value in vegetable culture under glass.

The special requirements for the applications of the steam-pan method of sterilization under forcing-house conditions will naturally suggest themselves. The use, wherever possible, of the steam boilers of the heating system is naturally a convenience in some respects, but where steam is carried for long distances through pipe, additional precautions may need to be taken to prevent the introduction of an excessive amount of water or wet steam into the pan. The size and shape of the pan should, of course, be such as to conform to the particular areas to be steamed. The duration of steaming usually should be increased for forcing-house soil above that recommended for seedbeds, the time required depending upon the type and condition of the soil and the parasite to be destroyed. In the case of nematode infestation, it is particularly important to sterilize the soil thoroughly to a considerable depth. A temperature of 140° F. or above for a few minutes is apparently required to kill nematodes. Since this pest may be harbored at considerable depth in the soil, it is advisable to attempt to secure such a temperature as deep as 8 to 12 inches. This may require as much as 1 hour of steaming under favorable conditions.

Certain objections present themselves with respect to soil sterilization by the steam-pan method in some greenhouses, since walls and pipes often interfere with covering all the soil with the pan. In such cases, a system of tile sterilization may prove most useful.

With this method, 4-inch tile lines are usually laid permanently 12 inches deep and $2\frac{1}{2}$ or 3 feet apart. The steam is turned into the ends of the tile lines, from which it escapes into the soil. It is advisable for those who propose to use the tile system to obtain as much information as possible on the subject from other sources before proceeding with the details of the installation.

For the sterilization of small quantities of soil in the greenhouse, especially for the culture of seedlings in flats or for potting purposes, various types of inexpensive box soil sterilizers may be used. The usual box sterilizer has a removable end and the bottom is pitched so as to drain toward this end. Perforated steam pipes are laid on the bottom and the soil is then filled in to a depth of $1\frac{1}{2}$ to 2 feet and covered. The steaming is complete when the surface soil reaches a temperature of 210° to 212° F.

Minor modifications of the various types of equipment to meet special requirements will naturally suggest themselves to those who are using or proposing to use the steam sterilization method.

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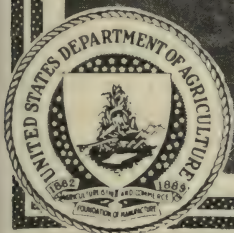
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FARMERS' BULLETIN No. 1630

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IRRIGATION PRACTICES IN GROWING ALFALFA



BECAUSE of the rapidity of its growth and the number of cuttings obtained during a season, alfalfa requires more water than most crops. Nevertheless water should be applied carefully in order to avoid waste and to prevent injury from over-irrigation.

There are several methods of applying water to alfalfa, their suitability depending on the character of soil and subsoil, climate, water supply, size of farm, and other factors. The most common are the border and check methods, and flooding from field ditches.

The border method consists of dividing a field into long narrow strips, by low levees, extending usually in the direction of the steepest slope. This method can be used best where large streams of water are available to the farmer.

The check method consists in surrounding nearly level plots of ground with low levees. The most favorable conditions for this method are light, sandy soils on an even slope of 3 to 15 feet to the mile or heavy soils on which it is necessary to hold water for some time in order that it may percolate to the desired depth.

Flooding the field from laterals or small ditches is a common method in the Rocky Mountain States. It can be used to advantage on slopes that are too steep for other methods. It costs little to prepare fields for flooding and the method is adapted to the use of small streams of water.

No fixed time can be recommended for watering alfalfa. In general it is best to irrigate as late as possible before the cutting and again after the crop has been removed if water is then needed. The appearance of the alfalfa, especially the color of the leaves, is an aid to the farmer in determining when water is needed.

This bulletin is a revision of and supersedes Farmers' Bulletin 865, Irrigation of Alfalfa.

IRRIGATION PRACTICES IN GROWING ALFALFA

By SAMUEL FORTIER, *Principal Irrigation Engineer, Division of Agricultural Engineering, Bureau of Public Roads*

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EXPERIENCE in the growing of alfalfa shows that it thrives best in the soil and climate of the arid and semiarid regions provided water is available for irrigation. It prefers a deep, well-drained loam soil, abundant sunshine, and a dry atmosphere, if its roots are well supplied with water. Certain varieties do well in Imperial Valley, Calif., 100 feet below sea level, while other varieties thrive on the San Luis plains of Colorado, 7,500 feet higher.

Over two-thirds of the acreage devoted to alfalfa in the United States is found in the 17 western States. Its importance to these States is due not only to its large acreage but also to its high yield and value.

THE ROOTS OF ALFALFA

Some knowledge of the location, extent, and functioning of the roots of alfalfa is desirable to enable the farmer to apply to the soil within the root zone the proper quantity of water at the right time and in the right way.

The topsoil should be moist enough from recent rains or an irrigation at seeding to supply the water needed by the plant until a number of true leaves appear and the taproot attains a depth of about 2 feet. The long, slender tap root of the young plant has a number of tiny branches throughout its length and when the top soil becomes too dry the branch roots in this area are likely to suffer. Hence an adequate soil moisture content should be maintained, if possible, in all parts of the root zone.

The normal distribution of roots of a mature plant grown in deep loamy soil free from hardpan or ground water may be expected

to conform somewhat closely to that indicated in Figure 1, which shows the weight of the roots in each 6 inches of a plant grown at Davis, Calif. under soil, climatic, and moisture conditions which produced an average seasonal yield of 8.71 tons an acre on 18 plots for a period of four years. The stems of representative plants were cut off just below the crown, and the weight of roots was determined in each 6-inch layer of soil. The fact that the roots near the surface, especially in the top foot of soil, represent a high percentage of the weight of all the roots is accounted for in part by the larger

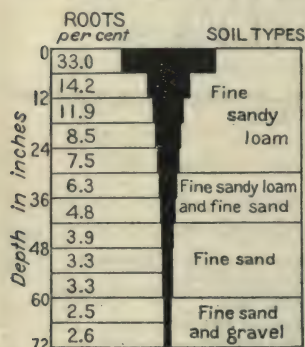


FIGURE 1.—Distribution of alfalfa roots by weight, under favorable conditions

Sometimes if the water table stands too high for a considerable period of time and the lower part of the taproot is continuously submerged, the latter eventually decays, causing the plant to suffer. This unfavorable condition is illustrated in Figure 2, which outlines the distribution of the feeding roots of alfalfa with a water table 3 feet below the surface. Where an infertile hardpan underlies a shallow soil, similar results often occur. The plants have no reserve-root zone from which to derive additional moisture and nourishment to overcome the effects of drought and other vicissitudes of a severe climate.

The chief function of the roots of alfalfa is to furnish a quantity of water and plant nutrients in solution adequate to the plant's requirements, which are very heavy. Under ordinary conditions about 750 tons of water is absorbed by the roots, drawn up through the stems, and mostly transpired by the foliage for each ton of cured hay harvested.

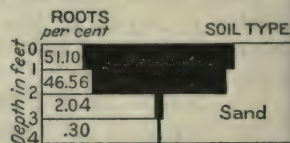


FIGURE 2.—Distribution of alfalfa roots with a water table 3 feet below ground surface

REMOVING DESERT PLANTS

The first step in preparing land for agriculture in the arid portion of the West is to remove the native desert plants. The smaller varieties of sagebrush and greasewood can be removed by deep plowing when the soil is moist. When the growth is 20 to 60 inches high it is removed usually by "railing," grubbing, and plowing. Railing¹

¹ Reproduced from the following publication: BEAN, R. P. DEVELOPING NEW LAND UNDER IRRIGATION. Wash. Agr. Expt. Sta. Pop. Bul. 136, 28 p., illus. 1926.

(fig. 3) consists in hitching a strong team to each end of a railroad rail and dragging it across the field. This process results in breaking off the shrubs at the ground surface. Subsequently they are raked into windrows and burned. On lands densely covered with heavy shrubs it may be necessary to do a second railing in the opposite direction, after which the brush is again raked and burned. The field (especially the knolls) is then deeply plowed, and the upturned roots are gathered and burned.

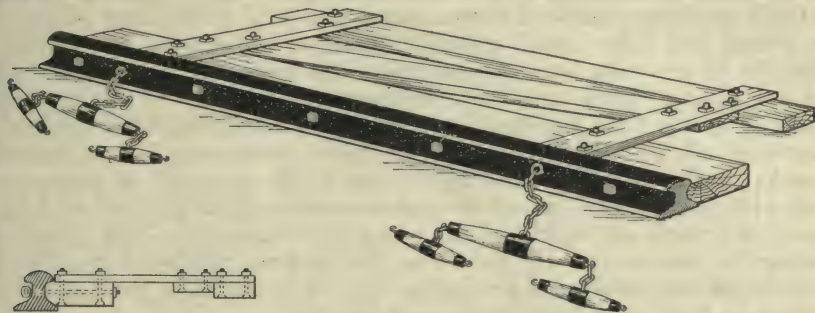


FIGURE 3.—A section of a railroad rail adapted to break down heavy sagebrush

Mesquite, a native of the Southwest, varies from a straggling, spiny shrub under adverse conditions to a widely branched tree under favorable conditions. It is removed ordinarily by hand grubbing.

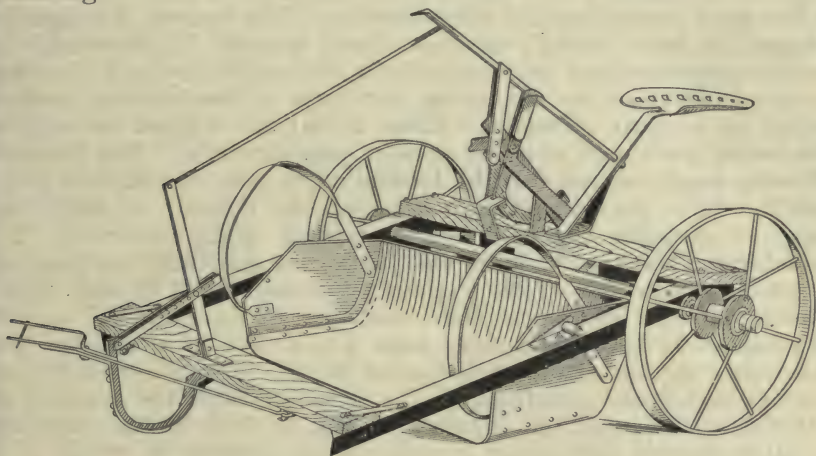


FIGURE 4.—A popular type of wheeled scraper

Preliminary operations in preparing land for irrigation do not always consist merely in getting rid of native vegetation. Sometimes sand dunes or other high spots must be lowered and depressions filled before a properly graded surface can be obtained. The plow and the scraper (fig. 4) are the implements most commonly used for this kind of work, but in recent years heavy scrapers operated by tractors have become popular, largely because of the rapidity with which they can do the work.

In preparing new land for irrigation it is seldom wise to complete the operation during the first season. The land is first roughly prepared and a cereal crop sown, irrigated in a crude way, and harvested. Meanwhile the roots of shrubs have decayed enough to be removed, filled-in soil has settled, and a permanent job of surface grading is possible, preparatory to seeding a perennial crop such as alfalfa.

In the central plain of California and some western valleys alfalfa seeding usually follows many years of continuous cropping to wheat and other small grains. Shallow plowing is the common practice in growing cereals, and when the operation is repeated year after a year a "plow sole" or "cultivation hardpan" is apt to form. This is not a true hardpan but rather a compaction of the finer particles of soil beneath the cultivated stratum. Deep plowing breaks up the plow sole, and by mixing a like quantity of unexposed soil with the topsoil—which long-continued cultivation and cropping have deprived of much of its organic components—the physical texture is improved. By following this course, worn-out grainfields which did not produce a profitable crop of grain have yielded in one season as high as 9 tons per acre of alfalfa.

FARM SYSTEMS OF IRRIGATION

In planning a farm system of irrigation, or irrigation layout, the slope and configuration of the surface, the character of the soil and subsoil, the quantity of water available, and the manner in which it is delivered deserve careful consideration. The method of irrigation adopted is based mainly on these four factors. A knowledge of surface slopes can best be obtained by a contour survey in which lines of equal elevation are run across the farm at intervals of about 6 inches in vertical elevation. These reveal the highest as well as the lowest parts and also the slope in any direction. The farmer's delivery headgate can then be located at or near the highest point and the farm divided off into the requisite number of fields and lanes, a suitable site for the farmstead being reserved. The boundaries of fields and lanes also determine generally the location, direction, and length of the various permanent farm ditches, pipes, flumes, or other conduits. The character of the soil can best be determined by making borings with a soil tube or soil auger and examining the borings in each foot of depth. The water-right contract or certificate pertaining to the farm indicates the quantity of water available, and the regulations and by-laws of the company or other agency furnishing it indicate the manner in which it is delivered.

In the future reclamation of arid lands much labor and expense might be saved and greater profits obtained by providing each settler with a skillfully prepared plan of an irrigation layout for his farm. The execution of this plan need not be completely carried out during the first or even the second year of occupancy. Its chief value would be in giving him a proper start and in guiding his subsequent operations.

Besides the factors already discussed, crops and profits influence the shaping of the irrigation layout since a valuable crop yielding

high returns calls for a more expensive and permanent layout than a cheap crop yielding low returns. Hence it is not feasible to adopt one standard plan of layout for many farms unless conditions are exceptionally uniform. As a rule each plan is adapted in design and construction to serve best the needs of the farm for which it is intended. The plan shown in Figure 5 is therefore intended to represent merely the general arrangement and the adaptation of methods to local conditions.

FARM DITCHES

Water is distributed over an irrigated farm during the crop-growing season by means of ditches, flumes, or pipes. The ditches are of two general kinds — temporary and permanent. Temporary ditches are formed in cultivated fields and last only a season, or less, after which they are leveled down and filled in by plow and cultivator in preparation for another crop. Permanent ditches are located usually along the margin of fields and are operated from year to year until modified by a change in the farm layout. To this latter class belongs the supply ditch which conveys water from the canal, stream, or other source of supply to the highest point of the farm.

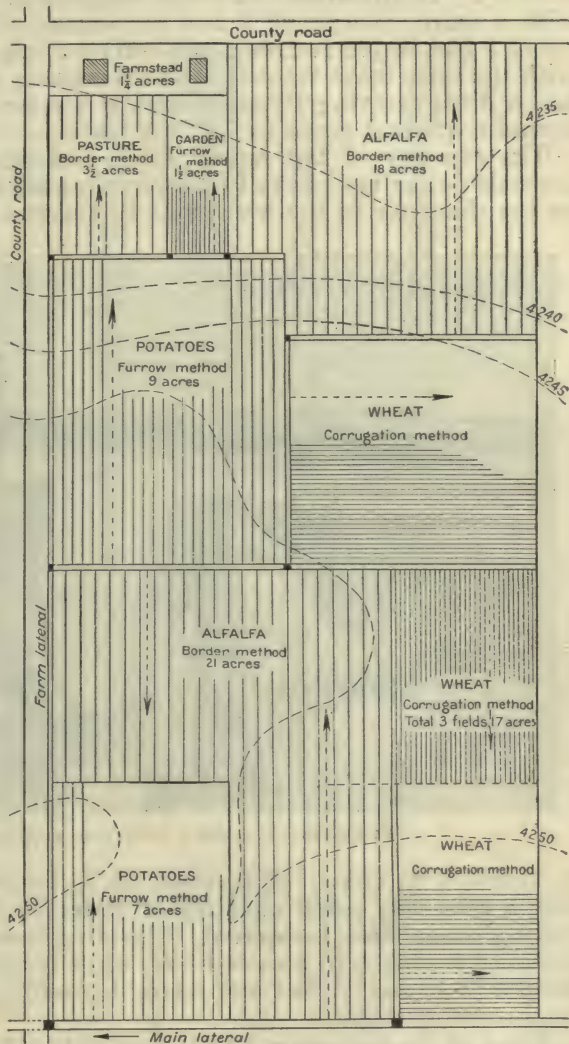


FIGURE 5.—The manner in which an 80-acre Idaho farm is irrigated

The flow of water in farm ditches should not be rapid enough to cause erosion, or sluggish enough to necessitate extra expense in providing large channels. Ordinary firm loam will not erode under a mean velocity of $2\frac{1}{2}$ feet per second, and for convenience in handling, this is about as fast as water should move in such channels. Some materials erode under slower velocities. Fine sand without any colloidal material to bind its particles is likely to erode in

velocities of $1\frac{1}{2}$ feet or less per second, sandy loam at $1\frac{3}{4}$ feet, and fine loam and silt at 2 feet per second.

The grade of ditches regulates the flow, but the proper grade to adopt in any given case depends also on the volume of water carried. The smaller the volume, the higher is the grade required for a given velocity. To illustrate: A ditch designed to carry 1.35 second-feet with a mean velocity of 2 feet per second should have a grade of about 1 foot in 100 feet, or 1 per cent; a ditch carrying 5 second-feet with the same mean velocity requires a grade of about 0.38 per cent; and a ditch carrying 10 second-feet at a mean velocity of 2 feet per second requires a grade of 0.22 per cent.

The capacity of the supply ditch and other permanent ditches depends on the method to be adopted in moistening the soil and also on the character of the water supply and the regulations governing

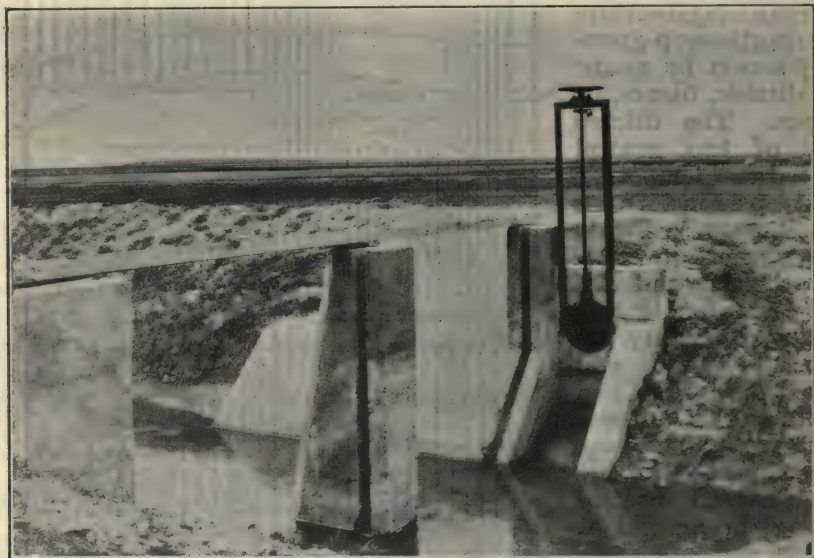


FIGURE 6.—A farmer's head gate and canal check

its delivery to users. If furrows are to be used mainly to wet the soil, a relatively small quantity of water or "head," varying from 1 to $2\frac{1}{2}$ second-feet, is required. Flooding from field laterals requires heads of from $1\frac{1}{2}$ to 3 second-feet, while borders and checks require from 3 to 10 second-feet and more, depending chiefly on the size of the border or check.

Some of the structures which constitute a necessary part of farm ditches are head gates or turnouts, measuring devices, division boxes, flumes, pipes, and check gates. These may be built of wood, concrete, steel, or combinations of these materials. A combined canal check and farmer's head gate built of concrete is shown in Figure 6. A common type of head gate made of steel is sketched in Figure 7.

In making small farm ditches after the ground is plowed, a ditch plow or lister is often used, followed by a small V-shaped crowder (fig. 8) and more or less hand dressing by shovels.

Medium-sized ditches may be made by wing plows or graders, and the large ditches by a wheeled scraper.

The cleaning of ditches is generally necessary in the early spring, although the removal of weeds by grazing is not confined to that season. In a ditch which erodes, the undercut banks need shaping, and in a ditch which silts, the deposits require removal. This may be done by hand shoveling or by any of the methods used in the original construction.

METHODS OF IRRIGATING ALFALFA

The methods of applying water to alfalfa differ widely because of the diversity of climates, soils and subsoils, ground-surface reliefs, the nature of water supplies, the sizes of farms, the funds available for preparing the land for water, the principal crops grown, and the early training and environment of irrigators. The most common methods are the border method, the check method, flooding from field laterals, and the corrugation method, with their modifications. There are other less common methods practiced in a few localities, such as the portable-pipe method and the subirrigation method.

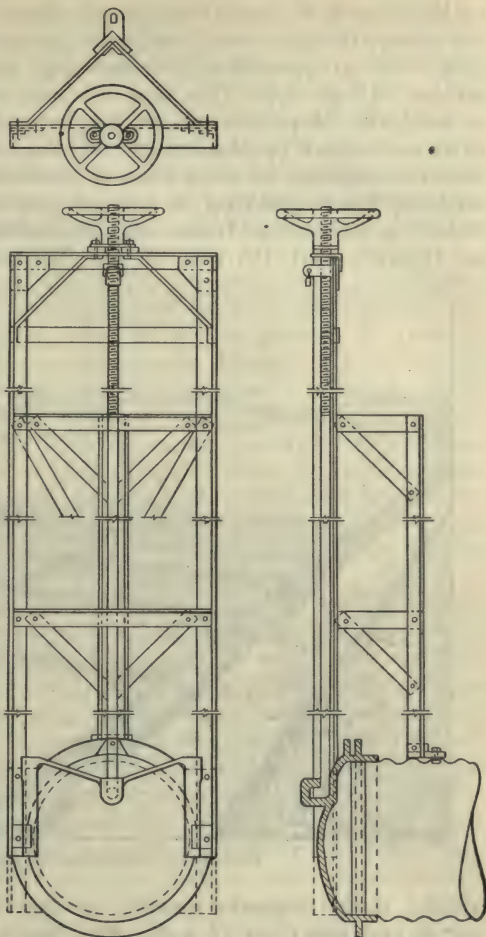


FIGURE 7.—Metal head gate attached to corrugated pipe

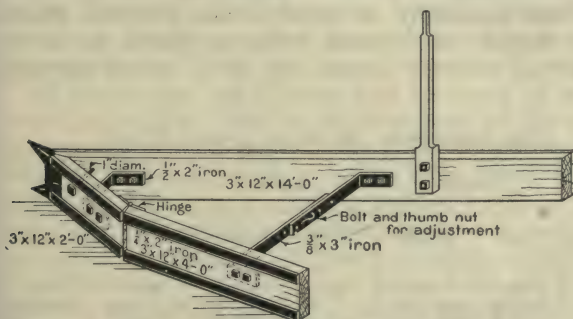


FIGURE 8.—An adjustable crowder

THE BORDER METHOD ²

The border method consists essentially of the division of a field or tract into long, narrow strips

² Described in Farmers' Bul. 1243, The Border Method of Irrigation.

or lands by low, flat levees, which extend in the direction of the steepest slope, if this is not so great as to cause washing of the soil or difficulty in spreading water, and confine the water into single strips. (Fig. 9.) The bed of each strip is carefully graded to a uniform slope except at the upper end, which is level for a distance equal to the width of the strip. If the contour of the natural surface is such that a uniform slope can not be obtained without much grading, a curved gradient is not objectionable, provided it increases from top to bottom of the strip. According to Beckett and Brown, of the University of California, the size

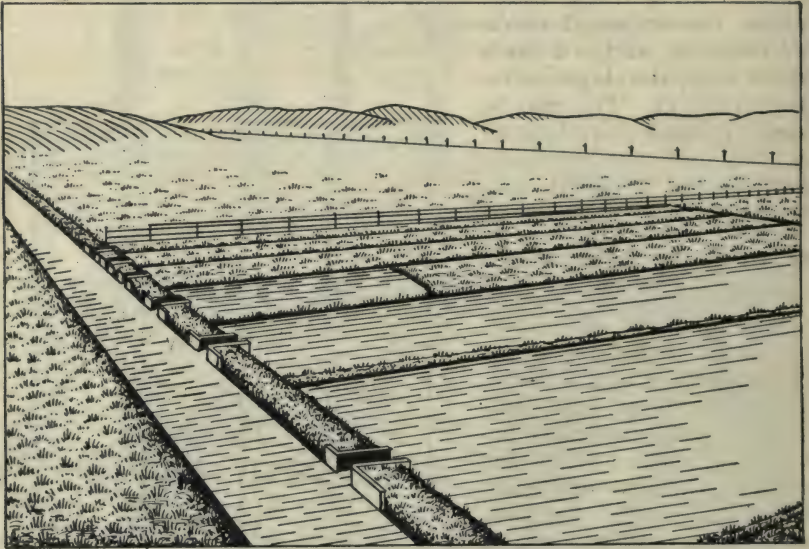


FIGURE 9.—Irrigation by the border method

of the strip depends mainly on the head of water used in flooding it and the type of soil. For heads varying from 1 to 8 second-feet and for the three main grades of soils, namely, sands, loams, and clays, they recommend the dimensions given in Table 1. They also recommend as the most desirable grades for strips when measured in inches per 100 feet: $1\frac{1}{4}$ to $3\frac{1}{2}$ inches for clay soils, $2\frac{1}{4}$ to 7 inches for loam soils, and $3\frac{1}{2}$ to 12 inches for sandy soils. In all types of soils, but especially in sandy soils, the top 20 to 30 feet of each strip should be formed without grade so as to permit the water to spread entirely across the strip before moving down the slope.

TABLE 1.—Border strip dimensions for three grades of soil

Head	Sand		Loam		Clay	
	Width	Length	Width	Length	Width	Length
<i>Second-feet</i>	<i>Feet</i>	<i>Feet</i>	<i>Feet</i>	<i>Feet</i>	<i>Feet</i>	<i>Feet</i>
1.....	20 to 30	200 to 300	30	300 to 400	30	440 to 660
1 to 2.....	30 to 40	300 to 400	30 to 40	440 to 660	30 to 40	660
2 to 4.....	30 to 40	440	40	440 to 660	50	660 to 800
4 to 8.....	40	440 to 600	50	660 to 880	50	880 to 1,320

The water to irrigate each strip is taken from the head ditch extending across the upper edge of the field and is controlled by an outlet box or border gate, although the gates are sometimes omitted to save in first cost of preparing for irrigation where the soil is not so light as to induce excessive washing. Check gates, canvas dams, or metal tappoons are used to hold up the water in the head ditch, causing it to flow into the strips. In many sections these temporary makeshifts are giving way to permanent structures, although the latter in many cases interfere with cleaning the ditches and increase its cost.

The border method is confined chiefly to the irrigation of alfalfa and grain, and in its various modifications is used extensively in Arizona, New Mexico, California, and, to a less extent, in Idaho, Utah, Montana, and other Rocky Mountain States. It is being adopted successfully also in Oregon and Washington. It can be used best under canals which deliver water to users in large streams, since the smallest head that can be applied successfully is seldom less than 2 or 3 cubic feet per second, while heads of 5 to 8 cubic feet per second are common. It is adapted especially to light, open soils, into which water percolates rapidly, as the use of a large stream confined between borders makes it possible to force water over the surface without great loss by percolation.

On the university farm at Davis, Calif., the strips or lands were formerly, on an average, about 50 feet wide by 900 feet long, but in recent years the widths have been reduced to 35 and 40 feet and the lengths to about 600 feet. Each border levee has a base 7 feet wide and is 12 inches high, when newly made, but settles to about 10 inches before the first crop is harvested. The bed of each strip is leveled crosswise and slopes regularly from top to bottom. In preparing the surface of this field the barley stubble was burned, then the soil was disked and roughly graded. The location of each border was marked out either by drag or by making a furrow. Sufficient earth to form the border was obtained by skimming the surface with scrapers. The scraper teams began next to the head ditch and worked down. They crossed and re-crossed the field at right angles to the borders, and as a scraper passed a border marking, it was dumped. Each scraper width of the borders was made up of two loads, but the last load overlapped the first by half the width of the scraper. The surface of each border was then leveled with an accuracy of 0.1 or 0.2 foot. The levees when first built were rough, irregular, and steep. They were cut down to a uniform grade by a reversible disk and then harrowed.

As noted, the size of strip and the head of water turned into it are more or less governed by the character of the soil. In sandy soil the spacing of borders varies from 20 to 30 feet in width and from 300 to 400 feet in length with a fairly large head, so as to wet the surface rapidly before much water is wasted by deep percolation. In retentive clay soils which absorb water slowly, longer runs are necessary, and a small quantity of water is allowed to run for a longer time. Sometimes, in heavy soils, low cross dikes are formed from side to side between borders, 100 feet or more apart, to pool the water and thus cause deeper moisture penetration.

Usually the only structures required are border gates to control the water entering each strip, and checks in the head ditch to raise the water level to such height that a sufficient volume will flow through the border gates. Border gates may be made of wood, a type of which is shown in Figure 10. However, untreated lumber is short-lived, and for permanent structures concrete is more economical although the first cost may be greater. A simple and inexpensive check gate in a head ditch is shown in Figure 11.

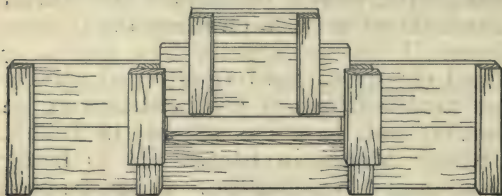


FIGURE 10.—Border gate of wood

THE CHECK METHOD

The essential provisions for irrigating by the check method consist in surrounding nearly level plots of ground with low levees, and conducting water to

each by means of a ditch and check box or gate. The spaces inclosed may be laid out in straight lines in both directions, so that their levee borders form a series of rectangles; or the levees may follow more or less closely the contour lines of the natural surface of the ground, thus forming contour checks. The most favorable conditions are a light, sandy soil on a comparatively even slope of 3 to 15 feet to the mile, supplied with an irrigation head of ample size.

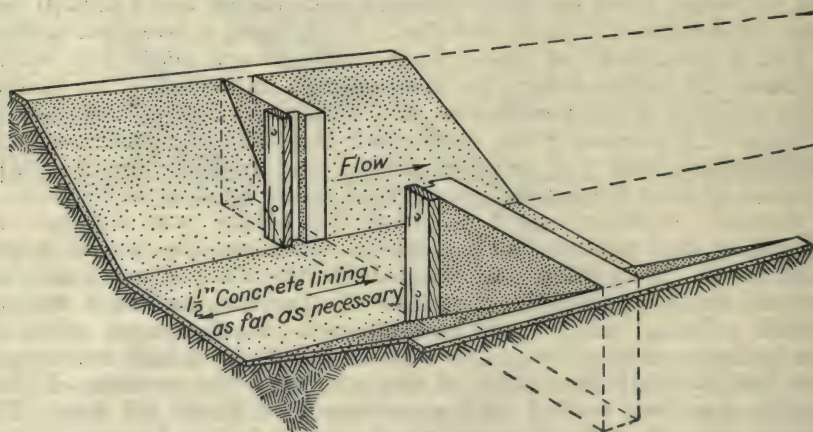


FIGURE 11.—Check gate in head ditch

This method is used also on heavy soils, where it is necessary to hold the water on the surface until it has percolated to the desired depth.

In California not only does the form of the checks vary, but their size as well, some of the smaller checks being less than one-half acre in area, while some of the larger contain more than 2 acres.

In the Modesto and Turlock irrigation districts the surface of the land under ditch slopes about 5 feet to the mile, and swales, hog wallows, and mounds make it too uneven to be irrigated without

first being leveled. The long side of each check should be on the flat slope and the short side on the steep slope. A fall of 3 to 5 inches between adjacent checks is best; usually it can be obtained by proper adjustment of the width of checks. The length of each rectangle will depend on the lengthwise slope as well as the location of the supply ditches. The field should be laid out in such a way that the levees may be built with a minimum handling of dirt. Rectangular checks possess many advantages over irregular contour checks, but if much good surface soil has to be removed in order to build the former, the advantages may be more than outweighed by the damage caused by grading and the extra cost.

On the west side of the San Joaquin Valley the land to be seeded to alfalfa is almost invariably formed into contour checks. The supply ditches are intended to be about 600 feet apart, and levees are built midway between them. The sides of the checks conform in a measure, but not exactly, to the natural contours, having a difference in elevation of 0.3 to 0.4 foot. Under ordinary conditions of soil and relief the cost of preparing dry-farmed land for check irrigation averages about \$25 per acre. Uncultivated desert land covered with shrubs is likely to cost 30 per cent more.

In the Modesto and Turlock irrigation districts the feed ditches are designed to carry large heads of 5 to 12 second-feet. These large heads are used by the farmers in turn for short periods of time, depending upon the acreage served. In the smaller checks a head of 5 second-feet will suffice, and if more water is available two or more checks may be irrigated simultaneously. Five second-feet flowing on a check containing 1 acre would cover it to a depth of about 5 inches in one hour. A part of the water so applied is always lost by evaporation, but the balance percolates into the soil to furnish moisture to the plants. The skillful irrigator begins with the highest checks and works down, for the reason that all water escaping through gopher holes or broken levees may be recovered and applied to dry checks. To reverse this order might result in over-irrigating the lower checks.

The chief advantage of the check method is that one man can attend to a larger volume of water and can irrigate 7 to 15 acres in 10 hours, making the cost of applying water less than that of any other method except possibly the border method. To counterbalance this important advantage, there are several handicaps which western farmers should consider. These are the removal of a considerable quantity of surface soil to form the levees, which frequently decreases the yield on the graded spots; the extra cost of preparing the land; the damage done to farm implements in crossing levees; and the fact that this method is not well adapted to a rotation of crops.

FLOODING FROM FIELD LATERALS

Flooding the surface of the ground from field laterals or small ditches is a common method of irrigating alfalfa. In Colorado, Wyoming, Montana, Utah, and Nevada, and to a less extent in other Western States, forage and cereal crops are irrigated in this way. This manner of wetting dry soil originated, it is believed, in the Mountain States, and the last half century has seen its gradual

extension, so that now it has not only become firmly established but is regarded as the method best suited to the conditions under which it is practiced. It can be profitably used on slopes that are too steep for other methods. Fields having a firm soil and a fall of 25 to 100 feet per mile have been flooded successfully. From this extreme the slope may diminish to less than 0.1 foot in 100 feet. Its cheapness is another feature which recommends it to the farmer of limited means. Ordinary raw land can be plowed and prepared for flooding at an expense of \$9 to \$15 an acre. Furthermore, the method is adapted to the use of small water supplies. In the Mountain States the irrigation systems have been planned and built to deliver water in comparatively small streams for use in flooding or in furrows, and water users should be certain that the larger volumes required for checks and borders can be secured before going to the expense of preparing their fields for either of these methods.

In grading the land for flooding it is not customary to make many changes in the natural surface. Only the smaller knolls are removed and deposited in the low places. An effort is made always, however,

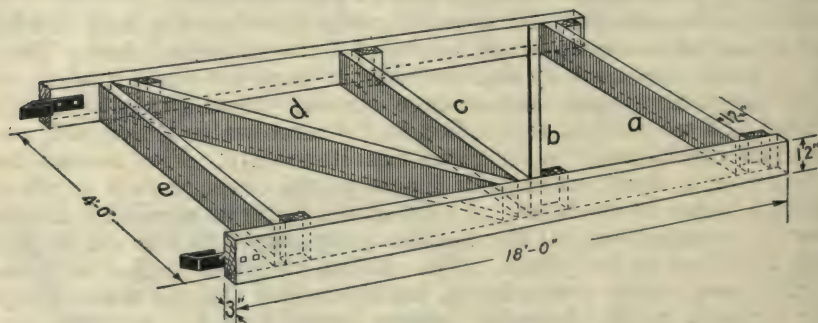


FIGURE 12.—Homemade drag or leveler: *a*, *b*, *c*, *d*, and *e* are shod with one-fourth by 4-inch steel edges

to make the farm laterals fit into the natural slope and configuration of the tract so as to bring the water to the high places. On steep slopes the laterals may be less than 50 feet apart; on flatter slopes, 200 feet or more. Whatever the spacing, it is always desirable to have the intervening slope as nearly uniform as possible. When the land in its natural state is uneven, the grading can be done by a scraper. If the field in its natural condition is comparatively smooth and level a homemade drag or leveler, as shown in Figure 12 serves the purpose fairly well.

The location of the ditches varies too widely to admit the adoption of a standard plan, but Figure 13 shows an arrangement of field laterals common to the Mountain States. A supply ditch, *ab*, is built on one side, and laterals *cd* and *ef*, branch out from it on a grade of 0.5 to 0.75 inch to the rod. These laterals are spaced 75 to 100 feet apart and are made with double-moldboard plows or listers, either walking or sulky type. Figure 14 illustrates another common method of irrigation.

In the vicinity of Fort Collins, Colo., the main lateral is built to the highest corner of the field, and the smaller laterals extend out

from it, spaced 75 to 225 feet apart, the spacing depending on the slope of the ground and the coarseness of the soil. The size of the laterals is governed by the available head, but on steep slopes and on soil that erodes readily small heads are best. Around Berthoud, Colo., the land is naturally of uniform, even slope, and little grading has been necessary. Heavy timber or iron drags are used to smooth the surface after it has been plowed so that the water will spread evenly. These implements are built in various ways and of whatever material is available. Worn steel rails are often used, two being coupled parallel about 30 inches apart. A team is hitched to each end of the drag upon which the driver rides. Going over a field once with such an implement usually is sufficient to make the surface uniform and smooth. The proper location for field laterals is evident to experienced irrigators without the use of surveying instruments, though in fields where the fall is slight it often is necessary to have a topographical survey made and the laterals located by an engineer. Field

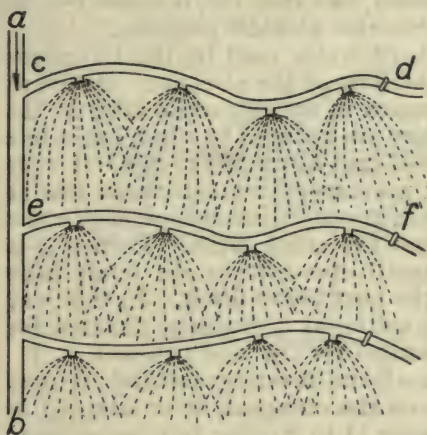


FIGURE 13.—A common method of locating field ditches in the Mountain States

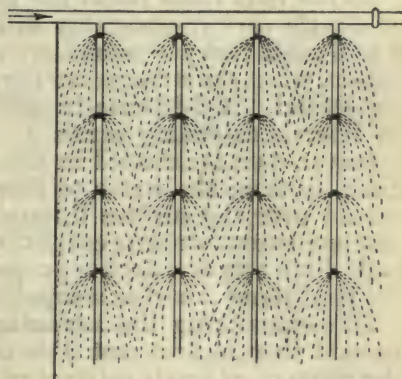


FIGURE 14.—Flooding fields from parallel field ditches

laterals always are so located that they cover the highest parts of the field, and for alfalfa their distance apart varies from 165 to 330 feet.

The head required for flooding from field laterals in northern Colorado varies from 2 to 3 cubic feet per second and is divided between two or three laterals. Canvas or coarse-manure dams are used to check the water in the laterals and force it out over the banks and down the slopes of the field. In less than three hours the upper foot of soil usually is thoroughly moistened. To apply one watering in this way costs from 50 to 75 cents an acre.

In Montana, where clover and alfalfa fields are to be flooded, the field ditches usually run across the field on a grade of 3 to 4½ inches per 100 feet. The spacing between ditches varies with the slopes, the smoothness of the surface, and the volume of water; but 80 feet is about an average. The head used is seldom less than 1½ or more than 4 cubic feet per second, the larger heads being divided between two or three ditches. A canvas dam is first inserted in each ditch or set of ditches, 75 to 100 feet below the head. The water is then

turned into each channel and flows as far as the dam, by which it is checked, and as a consequence it rises and flows over the low places of the lower bank, or through openings made with the shovel. When these small tracts have been watered, the canvas dam is moved down the lateral 75 to 100 feet, and again inserted in the channel to serve the next tract. In some sections it is customary to use two dams, one being placed below the other before the first is removed.

Manure or earth dams sometimes take the place of the movable canvas dams. After the ditches have been made, coarse manure is placed in small heaps within each ditch channel at suitable intervals, and each heap is covered with earth on its upper face to a depth of 1 to 2 inches. When this check has served its purpose it is broken and the water flows down until stopped by the next check. In some instances permanent wooden check boxes are inserted in each lateral, while in others the canvas dam is used. The thorough irrigation of 4 acres is considered a good 12 hours' work for one man. By using a head of 2 to 2½ cubic feet per second, two men can irrigate 7 to 10 acres in 24 hours at a labor cost of 85 cents to \$1.25 per acre.

In the Salt Lake Basin the heads of water used by the irrigators of alfalfa vary considerably with the flow of the streams. Heads of 4 to 6 cubic feet per second are common in spring, while later in the season, when the streams are low, they are reduced to 1 to 3 cubic feet per second. A field usually is divided into strips 200 to 500 feet wide by laterals extending across it. A permanent wooden check box or a canvas dam is inserted in the main supply ditch below each cross ditch, causing the water to flow into the cross ditch. Thence it is spread over the surface through small openings in the ditch bank and any excess water is caught by the next lower ditch. In this way each ditch serves a double purpose, acting as a drainage channel for the land above it and as a supply channel for the land below it.

In summarizing the advantages of the flooding method, it may be said that in first cost it is one of the cheapest, it is adapted to the delivery of small volumes of water (1 to 2 cubic feet per second) in continuous streams, it is particularly well adapted to forage and cereal crops of all kinds, it does not require removal of the topsoil from the high places to fill up depressions, and firm soil can be watered successfully even when located on steep and irregular hillsides.

Its chief disadvantages are the fatiguing labor required to handle the water, the small area which one man can irrigate in a day, the difficulty involved in applying water after dark, and the unequal distribution of water on the field unless more than average care is exercised. The latter objection is important, since uneven distribution decreases crop returns and wastes water.

CORRUGATION METHOD

In that part of the Columbia River Basin comprising the major portions of Oregon, Washington, and Idaho, moistening the surface soil by flooding is not generally practiced. This may be due in part to the fact that the soils of the irrigated valleys are derived largely from lava eruptions and are disposed to puddle when wet and bake when dry.

Accordingly, the corrugation method is commonly used, which consists of allowing small streams of water to flow through a series of narrow, shallow furrows or corrugations. This method is more fully described in Farmers' Bulletin 1348 F., The Corrugation Method of Irrigation.

The spacing of the corrugations depends chiefly on the lateral movement of the soil moisture. In tight soils the lateral spread of water may not exceed 8 or 9 inches, in which case the spacing of the corrugations is limited to 16 or 18 inches, whereas in open porous soils the lateral spread of water may be 18 to 24 inches, and the corrugations are proportionately farther apart. It is well, however, to have the horizontal movement of water overlap to some extent to insure a thorough wetting of all the soil in the root zone; and in ordinary loam soils the corrugations are usually not more than 3 feet apart.

The corrugation method permits the distribution of soil moisture by capillarity and gravity. In lava soils a 12-hour run is usually sufficient to wet the soil in the root zone. In less permeable soils

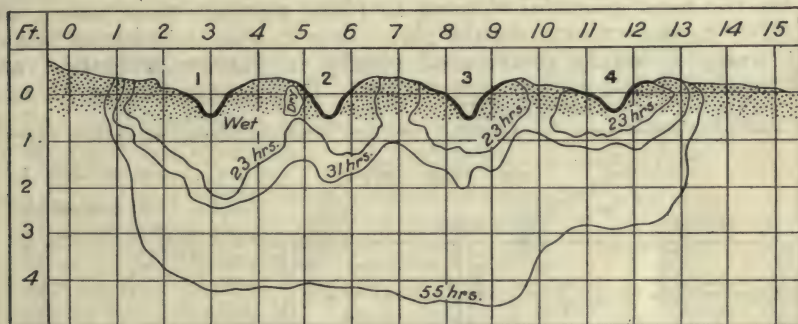


FIGURE 15.—Distribution of soil moisture from corrugations

the time required may be much longer. In the experiment illustrated in Figure 15 the water had reached a depth of $1\frac{1}{2}$ feet below the bottom of corrugation 1 at the end of 23 hours, and in 8 more hours had sunk about 6 inches farther. Corrugations 1 and 2 were $2\frac{1}{2}$ feet apart, and the water from them united in 23 hours to form a continuous curve with a cross-sectional wetted area of $7\frac{1}{2}$ square feet. Corrugations 3 and 4 were 3 feet apart, and for 23 hours the wetted area of each remained distinct, the former being $11\frac{1}{4}$ square feet and the latter $13\frac{1}{4}$ square feet. At the end of 31 hours the wetted sections of all had united, forming an irregular outline and comprising a total wetted area of about 18 square feet. At the end of 55 hours after the irrigation was begun the water had penetrated to a depth of $4\frac{1}{2}$ feet and had wet about 42 square feet.

The alfalfa grown in the Yakima Valley, Wash., is practically all irrigated by means of corrugations. The grading is usually done by buck scrapers (fig. 16), while a long, rectangular drag similar to the one shown in Figure 12, removes most of the surface inequalities remaining after the surface has been leveled roughly by the scraper.

The common practice is to run the furrows across the entire width or length of a field, and in consequence their length varies from 330 feet or less in small fields to 1,320 feet in large fields. Such furrows are usually too long. Farmers object to cutting up a field by head ditches, but in a climate like that of the Yakima Valley in midsummer

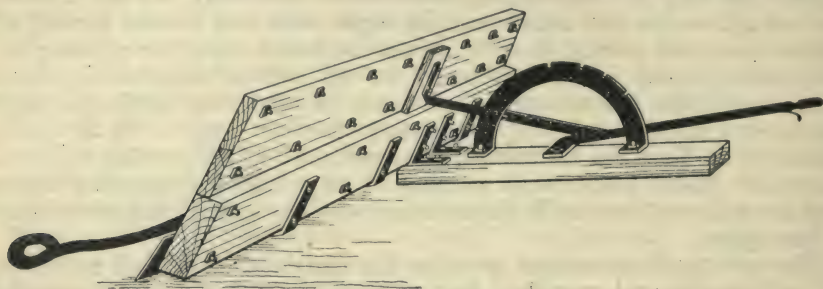


FIGURE 16.—Buck scraper

by far the most essential element in plant production is water, and all other considerations should give place to it. It has been shown that water is rarely distributed evenly in furrow irrigation and that much is lost by deep percolation. To increase the length of a

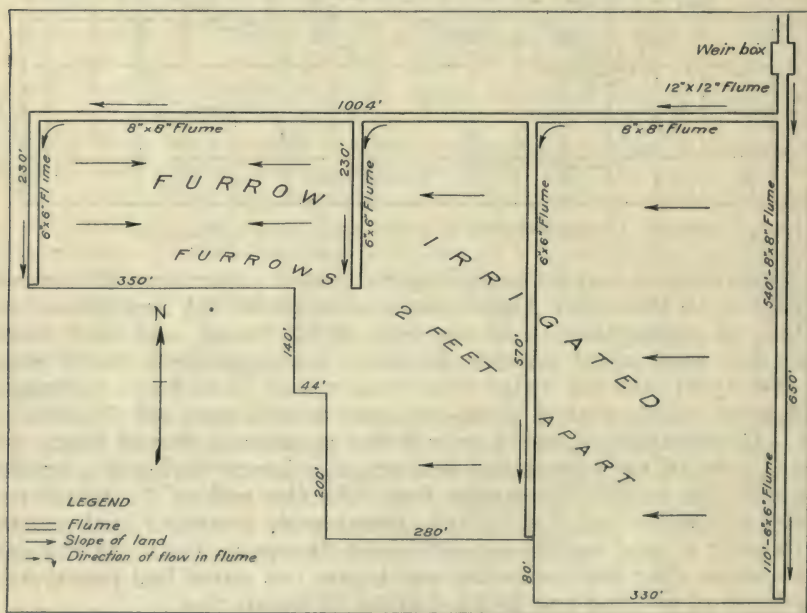


FIGURE 17.—An alfalfa field at Kennewick, Wash., irrigated by the corrugation method

corrugation much beyond 400 feet not only increases the loss but renders a uniform distribution more difficult to secure. Except in rare cases, this distance should be regarded as the limit for the length of furrows. In light, sandy soils having a porous underlying gravel stratum the length may well be reduced to 250 feet.

Figure 17 shows the manner of dividing an alfalfa field for the corrugation method at Kennewick, Wash. Wooden head flumes, either 8 by 8 inches or 6 by 6 inches, are placed along the upper boundary of each strip. Auger holes are bored through one side of the flume flush with the floor at points where water is to be delivered to the heads of furrows. A short piece of lath revolving on a nail controls the flow from each opening. Where the grade is steep, a cleat nailed crosswise to the floor of the flume just below each opening will dam back the water and increase the discharge.

When flumes are too costly the water is distributed to the furrows through wooden spouts set in the bank of an ordinary ditch. These head ditches when in operation are divided into a series of level sections by means of drop boxes which hold the surface of the water at the desired elevation. The spacing of these structures depends on the grade of the head ditch, and their cost averages about \$4 each. Spouts are made usually by nailing together four laths. In most communities a special lath is available, which is somewhat heavier than the one used as backing for plaster walls, being one-half inch thick, 2 inches wide, and 3 feet long. Four of these when nailed together cost about 7 cents, and each spout in place costs about 13 cents. Assuming that they are spaced 4 feet apart, the spouts for a square tract of 10 acres would cost \$21.50 or slightly more than \$2 per acre. Tin tubes, one-half inch in diameter, one to each furrow, have sometimes been used instead of the wooden tubes. When these

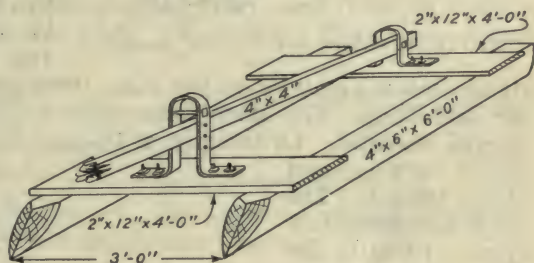


FIGURE 18.—Furrowing sled used to make corrugations

tubes are set one-half inch below the water surface, each tube discharges about 0.1 miner's inch, which is about right for a slope of 3 per cent. The length of the tin tubes is governed by the size of the ditch bank. The tubes are set while the water is in the ditch and are kept at the same level between check boxes. The cost of tin tubes 2 feet long is about \$5.50 per hundred. In many places neither flumes nor tubes are used. Water is taken through cuts in the ditch bank and divided among the corrugations as evenly as possible by directing it with a shovel. This practice reduces the cost of preparing the land for irrigation, but it increases the cost of applying water, and does not secure an even distribution.

Corrugations in alfalfa fields are most commonly made by the use of a furrowing sled. (Fig. 18.) Sleds with three runners are sometimes used, which reduce the time required for furrowing but do not produce furrows quite so satisfactory, since an obstruction under one of the outside runners will lift it and the middle runner and perhaps leave obstructions in the two furrows, which, if not removed, will cause the flooding of the surface when water is applied.

For the irrigation of most of the crops grown in the vicinity of Twin Falls, Idaho, the feed ditches are laid out across the field

as nearly parallel as possible, on a grade of 2 to 6 inches to 100 feet, and 300 to 500 feet apart. Corrugations are made in the direction of the greatest slope and approximately at right angles to the feed ditches. From the upper end of the field downward, a wooden check is inserted in the ditch at the end of each fall of 12 inches. Thus, if the ditch has a fall of 4 inches to 100 feet the checks are placed 300 feet apart. Each check box is provided with a removable flashboard which, when in place, backs the water to the next check above and at the same time permits the surplus water to flow over its top to supply the checks below.

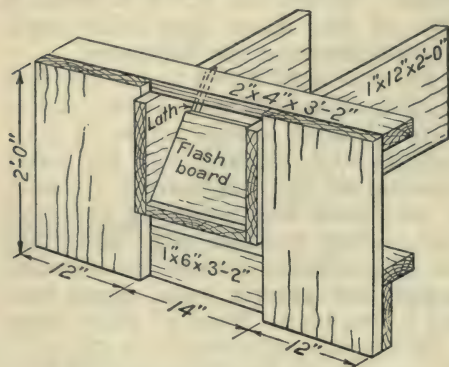


FIGURE 19.—Check box made of lumber

all of each set may be on the same level and that water may be had for puddling. The flow from each tube may be divided among several furrows. Ordinarily a 40-acre farm will require about 30 check boxes and 1,800 tubes. The check box shown in Figure 19 calls for 17 feet board measure of lumber, but a serviceable box can be made out of old packing boxes.

Some of the advantages of this method over ordinary furrow irrigation are that it makes possible the utilization of land having steep slopes and that it provides a constant head over the inlets of each set of tubes while the surplus passes down the field ditch. Its chief disadvantage is that it is wasteful of water.

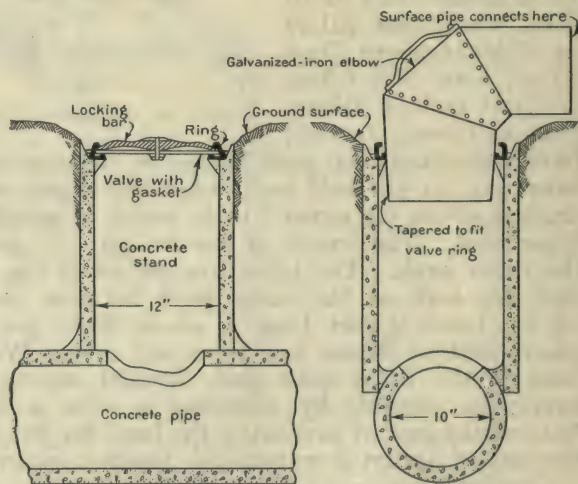


FIGURE 20.—Stand in concrete pipe

IRRIGATING ALFALFA WITH PUMPED WELL WATER AND PORTABLE PIPE

In southern California, where large areas of alfalfa are irrigated with water pumped from wells, at high expense, great care is exercised to prevent its waste. Concrete pipe lines are laid to

convey water from the pumping plants to the fields. These are 10 or 12 inches in diameter. The head lines, along the high sides of fields, are provided with stands about 100 feet apart. The type of stand used most commonly is illustrated in Figure 20. A section of 12-inch concrete pipe is cemented to the supply pipe. This is provided with a removable valve, permitting the insertion of an 8-inch galvanized-iron elbow, to which the distributing pipe can be attached. As shown, the top of the stand and valve is several inches below the general ground surface so as not to obstruct mowing machines. The 10-inch valve, which is used with a 12-inch standpipe, costs about \$5 installed.

In many instances water is forced through the pipe line by the pump, and usually an open standpipe is placed in the line near the pump to relieve the pressure on the pipe line when all valves are closed.

The cost of a head line for 40 acres, with 1,300 feet of 10-inch pipe, laid at 35 cents per foot, 12 stands and valves at \$7.75 each, and 1 basin at \$10, is \$558. Iron stands more convenient to open and close are not yet in general use because of their greater cost. Portable slip-joint pipe is attached to the stands in turn, and through it water is conveyed to all parts of the field. (Fig. 21.) This pipe is made

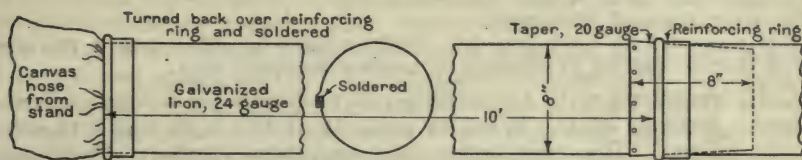


FIGURE 21.—Portable slip-joint metal pipe

of galvanized iron, usually 24 gage. It is 8 inches in diameter and is assembled in sections of several lengths, but the shorter lengths of 10 feet have been found to be most durable, and are preferred. The sections of some pipe of latest manufacture are 10 feet long, each being made of a single sheet of metal. Aside from the circumferential seam at one end, where the taper begins, a section of this pipe has only a longitudinal seam, which is soldered.

With a head of 60 miner's inches, one man can irrigate $2\frac{1}{2}$ acres in a 10-hour day. To irrigate a field the water is used from one stand for a strip equal in width to the distance between stands and with length from the head to the foot of the field. Since without reservoirs there must be an outlet for the water whenever the pump is in operation, it is best to have one stand open temporarily while the surface pipe is being connected to another. The best way to irrigate with surface pipe is to begin applying water at the upper end of the strip, and proceed toward the lower end by adding sections of pipe.

When care is used there need be no waste and no draining of surface water to prevent scalding. If too much water is being applied, it will flow down the field, and as the work approaches the lower side, it is easy for the irrigator to make proper allowance for the surplus. When one strip has been watered he begins at the upper end of the line by carrying the pipe across to the new location, section by section. The second stand is opened and the new connection made

before the first stand is closed. The leakage at the joints of pipes is slight, and the loss is not of consequence since it occurs on the land being watered.

The advantages of irrigation with portable pipe may be summarized briefly as follows:

A small stream may be handled effectively over a large area, and the irrigator may apply the stream on any part of the field he desires.

Losses which otherwise would occur by seepage in the conveyance of water over a field are prevented, and loss through gopher and squirrel holes is much reduced.

The fact that no field laterals are required effects a direct saving in the crop-producing area of a field, as well as in the time required to construct and repair these laterals.

With no laterals and the surface of the land free from obstructions, crops can be harvested with greater ease and with less wear and tear on farming machinery.

Land can be irrigated with little or no preparation, although it is better to level it to some extent if it is at all uneven.

Introduction of noxious weeds into a field is less likely to occur.

The disadvantages are:

Initial cost is high, especially where underground pipes form a part of the system.

Depreciation is high even under careful handling.

Leakage can not be wholly prevented.

The labor involved is onerous.

It is necessary to have pressure head on pipe in order that a fair-sized stream may be carried in conduits of medium sectional area.

Field irrigation with portable pipes undoubtedly is impracticable in many sections of the West on account of the high cost and other disadvantages. However, other sections, like southern California, possessing a scanty water supply, could well adopt the practice and thus extend the area watered with their small supply.

THE SUBIRRIGATION METHOD

Alfalfa is usually irrigated from the surface by one of the methods previously described. However, a small percentage of alfalfa lands—probably not more than 5 per cent of the total—is irrigated from below.

Frequently the seepage water from porous, earthen ditches and the waste water from irrigated areas passes through the subsoil of lower fields sufficiently near the surface to subirrigate them. In other places these seepage waters collect at the lower levels and raise the ground water near enough the surface to supply the plants with the needed moisture. It is questionable whether alfalfa growers should place much dependence on this mode of supplying moisture. What is gained in not having to irrigate usually is more than lost in damage done to both soil and crop by the rise of the ground water, which is almost certain to be followed by an accumulation of alkali near the surface if it is at all prevalent in the soil. Moreover, the fact that an alfalfa field subirrigates is usually an indication that the ground water is rising dangerously near the surface, and observations should be made to determine whether the level is above the danger limit.

One of the best ways of making such determinations is by means of test wells. These are made by boring holes from 2 to 4 inches

in diameter in different parts of the field and noting at regular intervals the elevation of the ground water in each. Where the subsoil is a clay or a clay loam no lining will be necessary other than a joint of drain tile or a short wooden tube. Where the subsoil is loose it may be necessary to line the wells with thin galvanized iron or a wooden box. The wells may be connected by a line of levels, the elevations being taken on the tops of stakes driven beside the wells. These well records, if taken at monthly intervals for several years, will show at a glance not only the position of the ground water, but also its rise and fall throughout the seasons. Whenever it is found that the water table stands for any considerable time at less than 4 feet from the surface there is reason for alarm, and measures should be taken to prevent such an accumulation of seepage waters or to remove the surplus by drainage.

Alfalfa is subirrigated also from the flood planes of streams. On bottoms the danger from alkali is not great, because little is present and the height of the ground water is governed by the condition of the stream. It often happens that when the water table is at its highest point the alfalfa plants are dormant or nearly so, and as a result are not injured readily.

In the vicinity of St. Anthony, Idaho, there is a subirrigated area of about 60,000 acres. Water is conveyed to the farms of this tract in the usual way and is then diverted into shallow field ditches. These ditches are about 3 feet wide and 6 inches deep, are spaced 100 to 300 feet apart, and extend lengthwise of the field. Crops are planted in the spring when the ground water is low; then a stream is turned into each ditch and kept there day and night until the ground water rises near enough to the surface to supply the moisture needed by the plant roots. Thereafter the height of the ground water is regulated by the quantity of water turned into the supply ditch. The rise and fall of the ground water is determined by means of small boxes set in the ground 3 to 5 feet deep. Twenty to thirty boxes usually are required for each 80-acre farm. About half the water is turned out of the main canal prior to September 15 to permit the land to dry for the harvesting of crops. After the crops are removed, a small stream is left running in the main canal all winter, but notwithstanding this supply the ground water usually falls 6 to 20 feet below the surface during the fall and winter months.

QUANTITY OF WATER REQUIRED

Alfalfa requires more water than most crops. This is accounted for readily by the character of the plant, the rapidity with which it grows, the number of crops produced in a season, and the heavy seasonal tonnage obtained. Its roots are not only deep but well distributed to draw plant food from the most fertile layers of soil and moisture from the wettest layers, while that part which is above ground is well provided with leaves from which water is transpired in large quantities. The rate of growth varies with soil, temperature, and other factors, but under favorable conditions a crop matures in about 35 days. Where the soil moisture is derived solely from an annual precipitation of 20 inches or less, little moisture may remain in the root zone after the first crop is harvested and a second crop can not be grown. However, if most of the rain occurs in the summer the

second crop may be the larger. In other localities killing frosts shorten the growing period to such an extent that only one or two cuttings in a season can be made. Ordinarily, however, when the deficiency in rainfall is made up by irrigation and the period of growth is long enough, three to six crops are harvested, yielding a seasonal tonnage of 3 to 7 tons per acre.

There is a wide variation in the seasonal quantity of irrigation water required by alfalfa. Two of the most influential factors are climate and soils. Temperature determines the length of the growing period and the number of crops that can be grown yearly, while precipitation if it is effective, lessens the quantity of irrigation water needed. The quantity of irrigation water needed under an effective rainfall of 12 inches is obviously less than it is under an effective rainfall of 3 inches. Soils cause a variation in that more water is wasted in irrigating pervious than impervious soils.

Many experiments have been made by the Bureau of Public Roads, to determine the water requirement of alfalfa. Some of these experiments were made in tanks under controlled conditions, others on plots under partially controlled conditions, and the remainder on selected fields.

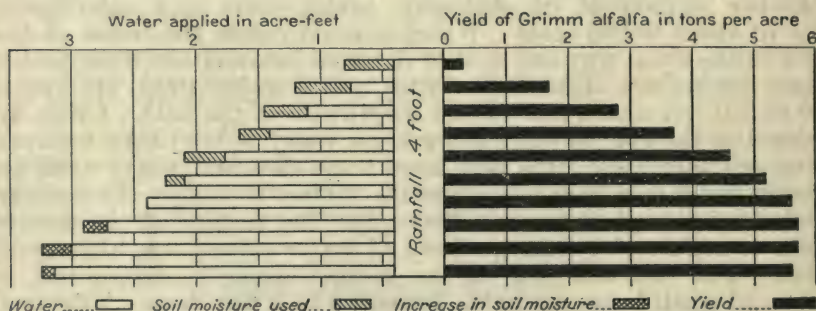


FIGURE 22.—Yields of alfalfa obtained by the use of various quantities of water at Brooks, Alberta

The results from the tank experiments seem to establish the following facts: (1) For the first few months the energies of the plant are devoted more to the establishment of a root system than to the production of stems and foliage; (2) the least demands for water occur in early spring, by reason of low temperatures and other unfavorable conditions, and immediately after a crop is harvested; (3) the demand for water is fairly constant during growth but tends to increase slightly up to the blooming stage; and (4) within a narrow range the consumption of water by the alfalfa is fairly constant, regardless of the quantity of water applied during the season or at each irrigation.

In southern Alberta experiments to determine the water requirements of alfalfa were carried on by the Dominion Government. The mean results of four seasons of plot experiments are shown graphically in Figure 22. The plot which received no irrigation water, as indicated in the first line at the left of the graph, and 0.4 foot of rainfall, drew on the soil moisture to the extent of another 0.4 foot in order to produce one-third ton per acre. The second plot received 0.35 foot of irrigation water in addition to the rainfall but also

drew on the soil moisture for 0.45 foot to produce a yield of 1.7 tons per acre. Similarly the third, fourth, fifth, and sixth plots, which received, in the order given, increased quantities of irrigation water, likewise obtained more or less additional moisture from the soil. In the seventh plot, which received a total quantity of 2.4 feet, the needs of the plants for water seemed to have been satisfied, since there was slightly more moisture in the soil at the close of the season than at the beginning. Nevertheless plot 8 required 2.9 feet of water in all to produce the maximum seasonal yield of 5.7 tons per acre, although nearly 0.3 foot remained in the soil unutilized. Beyond this stage the additional water applied tended to decrease slightly the seasonal yield.

Similar experiments carried on by the author at the Montana Agricultural Experiment Station, Bozeman, Mont., showed a variation in yield of from 4.61 tons per acre with the application of 1.2 feet of irrigation water and rainfall to 7.68 tons per acre when a total depth of 3.7 feet was applied.

In the Yellowstone Valley, Mont., two heavy crops and a third light crop can usually be grown. Nearly half of the yearly precipi-

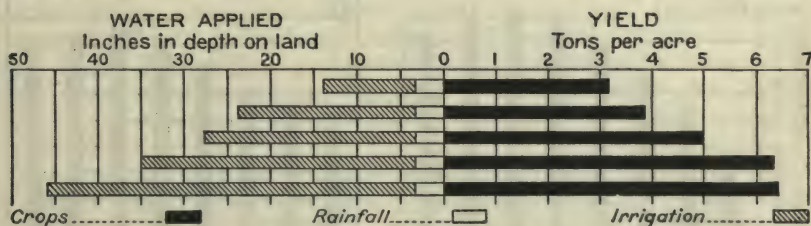


FIGURE 23.—Relationship between average yield of alfalfa and average water applied at Gooding, Idaho

tation of 14 inches occurs in April, May, and June, so that the first crop is far advanced before irrigation water is required. Experiments carried on for three years showed that with an average seasonal application of 2.56 acre-feet of water per acre, including rainfall, the average yield of hay was 4.15 tons per acre.

In similar investigations in northern Colorado the six alfalfa fields which produced the highest yields (4 to 6 tons per acre) used 3.23 acre-feet of water, including rainfall. In the lower Arkansas Valley of Colorado an average yield of 3.21 tons of hay per acre was secured with the use of 3.23 acre-feet of water.

The results of tests to determine the most economical use of irrigation water on alfalfa in southern Idaho are shown graphically in Figure 23.

In New Mexico a seasonal yield of 5 to 6 tons of hay per acre requires on an average about 4.25 acre-feet of water.

The results of plot experiments at Davis and Delhi, Calif., are shown in Figure 24.

NUMBER AND FREQUENCY OF IRRIGATIONS

The water requirements of alfalfa exceed those of almost any other crop. This plant possesses a large and well-distributed root system, which develops early in its life and requires considerable

water for its proper maintenance. These two major factors should be kept in mind in irrigating alfalfa. Except during its dormant stages, the plant should be furnished with sufficient water to enable it to grow continuously at a maximum rate. It is true that the cutting and removal of a crop produces a radical change, since less water is needed until the foliage of the subsequent crop again demands its adequate quota of water. Except during this interval, however, about the same quantity of water is needed during the entire period of growth.

Alfalfa commonly receives careless treatment at the hands of western irrigators. When water is available and is not needed for other crops it usually is turned on the alfalfa fields or meadows whether they need it or not. There is no question that yields of alfalfa and the life of the stand might be increased considerably if more care were used in finding out when to apply water. In each kind of soil and under any given set of climatic conditions there is a certain range of soil-moisture condition which will give the best results.

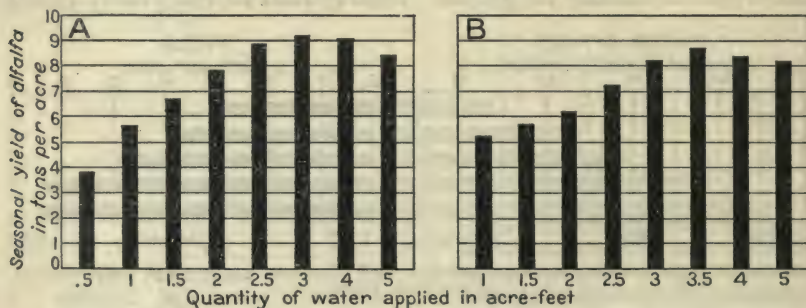


FIGURE 24.—Results of plot experiments (A) at Davis, and (B) at Delhi, Calif.

There is a considerable range between the moisture percentage at which the soil is too wet for a normal growth of the crop and that at which it is too dry. To use water most economically the limits of soil moisture percentages within which the crop grows best should be determined, and the practice adopted should be such as to keep the soil moisture within these limits at all times.

Under the present unskillful practice it is impossible to maintain uniform soil-moisture conditions for any length of time. The soil is likely to receive too much or too little water, or else it is deluged with cold water at a time when it needs only heat and air. The number of irrigations required depends upon the depth and nature of the soil, the method of applying water, the depth to ground water, the number of cuttings, and the rainfall, temperature, and wind movement. The number of irrigations and the time of irrigating depend to a considerable extent on the number of cuttings and the time of cutting. It is necessary to have the fields dry enough to permit the use of machinery for harvesting the crop, and consequently they can not be irrigated just before the cutting. But if light soils are not irrigated before the cutting, they may not retain enough moisture to start the new crop and maintain its

growth until the old crop is removed. Usually it is considered the best practice to irrigate as late as possible before the cutting and again after the crop is removed if more water is needed.

Other things being equal, more frequent waterings are required in the warm sections of the Southwest than in the cooler portions of the North. The number of irrigations per year for alfalfa ranges from 3 in Montana and Wyoming to as many as 12 in parts of California and Arizona. In localities where water is scarce during part of the season the number of irrigations, as well as the amount of water used each time, depend on the available supply. It is a common practice to apply frequent and heavy irrigations in the spring when water is abundant and to water less often and more sparingly when the supply is low.

RISE OF GROUND WATER AND ITS EFFECTS ON ALFALFA

In their natural state the typical soils of the arid region are characterized by their looseness, dryness, and absence of high water table. The diversion and use of large quantities of water in irrigation soon change some of these natural conditions. A part of the flow in earthen channels escapes by seepage and still larger quantities percolate into the subsoil from heavy surface irrigations. The waste water from these and other sources collects in time at the lower levels and raises the ground water. Usually this rise is noticed first in wells, a permanent rise of 5 feet in a year being not uncommon.

This rise of the ground water is an advantage, provided it does not go too high. It lessens greatly the cost of sinking wells, reduces the quantity of water needed in irrigation, and furnishes a reservoir from which water can be pumped to supply other lands.

It is not until the water level encroaches upon the feeding zone of valuable plants that its injurious effects are felt by the farmer. Its near approach to the surface may prove so disastrous that its upward trend should be noted with the greatest care. A series of test wells provides the best means of making such observations.

There is some difference of opinion as to what subsurface depth marks the danger line for alfalfa. It has been shown by soil physicists that water may be withdrawn by capillarity from saturated soils to depths varying from 4 to nearly 5 feet, depending on the character of the soil. This fact is important because when the ground water is brought to the surface and evaporated the salts held in solution are deposited at or near the surface. If these salts are sodium salts, they are usually grouped under the common term "alkali," and their accumulation at and near the surface will in time destroy the alfalfa. Therefore when alkali is present in harmful quantities in the ground water, the water should not be allowed to rise to a height where the effect of the alkali will be felt within 4 feet of the surface.

In soils free from alkali but saturated with water there is not the same necessity for holding the ground water continuously below the so-called "danger line." In parts of Kern County, Calif., the ground water sinks to 8 feet below the surface of alfalfa fields in summer, but rises to within 1.5 feet of the surface in winter.

There is no indication of root rot, and the plants have retained their full vigor. Numerous cases might be cited to show that the rise of water to within a foot or two of the surface for comparatively short periods of time does little injury to the plants. On the other hand, wherever water stands continuously during the irrigation season within a foot or two of the surface it is almost certain to destroy in time that part of the tap root which is submerged.

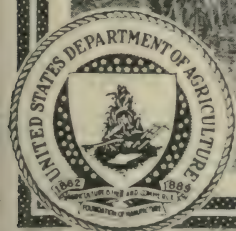
The remedy to apply to a high ground-water level is drainage by means of open ditches, covered tiles, or by pumping from wells, but much can be accomplished by the exercise of preventive measures in allowing less waste water to accumulate in the soil and subsoil.

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1631

BROOMCORN Growing and Handling



BROOMCORN production has been shifting toward the cheaper lands of the Southwest. The leading States in the production of broomcorn at the present time are Oklahoma, Kansas, Colorado, Illinois, New Mexico, and Texas. The United States consumes and exports about 50,000 tons of brush annually. The average yields of brush are about 600 pounds per acre under favorable conditions and 200 to 300 pounds under limited moisture or other unfavorable growing conditions.

Broomcorn varieties are classed as standard, western dwarf, and whisk dwarf. At least seven distinct varieties are grown in this country.

Previous to harvest time the growing of broomcorn is very similar to that of other intertilled crops, such as corn, grain sorghums, and cotton. Planting in early June usually produces the best crop in most sections. The plants should be spaced about 3 inches apart in the row under humid conditions and 6 to 9 inches apart under semiarid conditions.

Standard broomcorn usually is harvested by breaking over or "tabling" the stalks and cutting off each brush with a knife. Dwarf broomcorn brush usually is pulled from the standing stalk. The crop should be harvested as soon as the entire brush turns green.

Threshing and baling the brush are done with special machines. Large crews of men usually are necessary for harvesting, threshing, and baling. The brush is cured either in special sheds or in ricks in the open air. The best brush is that which has a uniform bright-green color with fine, straight, smooth, nearly round fibers and which has been properly harvested, threshed, cured, and baled.

Mature broomcorn seed is nearly as valuable as oats for feed, but when the brush is harvested at the proper stage the seed is so immature as to be practically valueless.

In general the cost of growing broomcorn is about equal to the price received for the brush, but is much higher or lower in some seasons.

This bulletin supersedes Farmers' Bulletins 768, Dwarf Broom Corns, and 958, Standard Broom Corn.

BROOMCORN GROWING AND HANDLING¹

By JOHN H. MARTIN, *Agronomist, Office of Cereal Crops and Diseases, Bureau of Plant Industry*, and R. S. WASHBURN, *Assistant Agricultural Economist, Division of Farm Management and Costs, Bureau of Agricultural Economics*

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BROOMCORN AND ITS USES

BROOMCORN belongs to that group of plants known as sorghums. It differs from the other sorghums in that it produces heads having long branches which form a brush. The brush is used almost exclusively for making brooms and whisk brooms.

The origin of broomcorn is not known, but it has been grown in Europe for more than 300 years. The crop appears to have been first grown in the United States by Benjamin Franklin. Broomcorn was first grown commercially in this country in the Connecticut Valley near Hadley, Mass., about 1797. From there the industry advanced westward. Successive centers of production have been the Mohawk Valley of New York, the Scioto Valley of Ohio, east-central Illinois, the Smoky and Arkansas Valleys of Kansas, the Washita Valley of Oklahoma, and the section comprising southwestern Kansas, northwestern Oklahoma, southeastern Colorado, and northeastern New Mexico. Broomcorn also was formerly grown rather extensively in Virginia, Tennessee, Missouri, Iowa, and Nebraska. In general, the westward movement of broomcorn represents a shifting to cheaper lands.

BROOMCORN PRODUCTION²

For many years the average annual disappearance of brush in this country for domestic manufacture and for export has been about 50,000 tons. The total consumption of broomcorn in the United

¹ This bulletin is based upon (1) records of the costs and practices in growing broomcorn obtained from 190 farmers in Illinois, Kansas, and Oklahoma in 1928 (a survey conducted by the Bureaus of Plant Industry and Agricultural Economics in cooperation with the Illinois and Kansas Agricultural Experiment Stations) and (2) experiments with broomcorn on several field stations of the U. S. Department of Agriculture in Oklahoma, Texas, New Mexico, and Kansas for the last 20 years.

² The average annual production of broomcorn brush in the principal producing States in the United States during the 10-year period from 1920 to 1929 was slightly less than 50,000 tons. The leading States in the production of broomcorn in 1929, with the estimated tonnage produced, were as follows: Oklahoma, 15,100; Colorado, 9,100; Kansas, 7,100; New Mexico, 6,000; Illinois, 4,500; Texas, 1,200; and Missouri, 800. Other States produced only small quantities, mostly for local broom factories.

States is not increasing. During this period the population of this country has been increasing rapidly, but the consumption of brooms has not kept pace with this growth. The increasing use of vacuum cleaners, dust mops, carpet sweepers, push brooms, and brushes and brooms made from tropical fibers has caused broomcorn brooms to be used less and less.

There is little likelihood of increasing the present consumption of broomcorn in this country. The possibility of creating a foreign market for broomcorn brush is not encouraging, because broomcorn can be grown in many parts of the civilized world when there is sufficient demand.

At the present time there are three important broomcorn-producing districts or centers. The oldest of these, often referred to as the central district, is east-central Illinois, including Coles, Douglas, Cumberland, Moultrie, Shelby, and Jasper Counties, with Mattoon as the chief marketing point. This district is in the heart of a commercial corn, small-grain, and livestock region where the soil is mostly very fertile and the annual precipitation about 38 inches. Only standard broomcorn is grown in Illinois.

Another important broomcorn center is the Washita Valley in McClain, Grady, and Garvin Counties in south-central Oklahoma. Lindsay, Okla., is the leading broomcorn market there and probably in the world. Standard broomcorn is grown in the Lindsay district, and most of it, like the Illinois crop, is of high quality. The best yield and quality of brush are obtained on the rich bottom lands, but considerable broomcorn also is grown on the uplands. The average annual precipitation is about 32 inches. Cotton also is an important crop in the Lindsay district.

Much of the broomcorn at the present time is produced in what is known as the western or dwarf broomcorn district, comprising western Oklahoma, southwestern Kansas, southeastern Colorado, and eastern New Mexico. The average annual precipitation varies from about 30 inches, in the Washita Valley of Oklahoma west of the Lindsay district, to about 15 inches in Colorado. The soil types vary widely in this district, but most of the broomcorn is grown on the lighter soils and much of it on land too sandy for successful wheat production. Some broomcorn is grown in the panhandle of Texas adjacent to the Oklahoma and New Mexico sections, but the principal broomcorn section of Texas now is in Bee County, in the southern part of the State. Broomcorn is no longer an important crop on the irrigated lands of the lower Rio Grande. Both dwarf and standard broomcorn are grown in the western district, and until recent years the dwarf greatly predominated.

For the most part the methods of growing broomcorn in the western district usually are much less intensive than in the Illinois and Lindsay districts, and the quality of the brush is poorer. Some growers in the western district are more painstaking than others and are able to produce a high quality of brush in favorable seasons.

Under favorable conditions broomcorn yields an average of about 600 pounds of brush per acre in east-central Illinois and slightly less in the Lindsay district. In the western district the average yields are only 200 to 300 pounds per acre, owing to the limited rainfall and less intensive farming methods. In the better portions of the western district high yields of brush are sometimes obtained in favorable seasons.

WHERE BROOMCORN IS ADAPTED

Broomcorn can be grown in practically every State in the Union. It will produce a fair quality of brush wherever the temperatures are high enough for corn for grain to grow well.

Broomcorn has been, or still is, grown on a commercial scale from Massachusetts and Virginia to California. It can be grown successfully anywhere in the United States except in the extreme Northern and Northwestern States, where temperatures usually are too low. It is possible to grow the crop in many localities where it is not now grown except on a small scale for local consumption. The limited demand for the crop, however, prevents it from being grown on a wide scale. Broomcorn has not been able to compete with other intensive crops on expensive irrigated land.

Broomcorn is a heat-loving plant, and the best brush is produced where the summers are rather warm and where soils are fertile and fairly well supplied with moisture. Deep alluvial soils usually produce brush of higher yield and quality than the shallower soils on the uplands, and much of the broomcorn in the past has been grown on rich river-bottom land. Poor soils and cold or extremely dry weather result in inferior brush.

VARIETIES

The varieties of broomcorn grown in the United States may be divided into three groups—standard, western dwarf, and whisk dwarf. Not less than seven distinct varieties are grown in this country, and several strains of some of these are known. It is important to know the variety and its characteristics when seed is obtained.

In addition to the varieties listed below there have been developed types of broomcorn having sweet juicy stalks like the sweet sorghums. These types are grown only on a limited scale and usually do not produce a good quality of brush.

STANDARD GROUP

Standard broomcorn usually grows to a height of from 7 to 15 feet. It bears a brush from 16 to 24 inches or more in length. The "handle" or stem of the brush is 8 inches or more in length, is strongly attached to the stalk, and is cut at harvest, being pulled only rarely. The brush usually is pushed entirely out of the boot by the lengthening of the stem at heading time.

The brush of standard broomcorn is used for making all types of brooms and whisk brooms.

At least three distinct varieties of standard broomcorn are grown in this country, viz, Evergreen, Black Spanish (Black Jap), and California Golden (Aksarben).

EVERGREEN

Evergreen is the leading variety of broomcorn in Europe and has been grown in this country for 80 years or more. There are many strains of this variety in existence, the most widely grown at the present time being Tennessee Evergreen (Tennessee Improved Evergreen), White Italian, Missouri Evergreen, and Austrian. White Italian is reported to be more uniform and of better quality than the other strains. It is a selected strain which has been grown for some years in Illinois and is now the leading sort there. The Tennessee Evergreen, Austrian, and Missouri Evergreen are practically identical. Some strains of Evergreen are distinctly taller and later than the strains mentioned, but they are not favored because the brush usually is too long and coarse for making the best brooms.

Evergreen broomcorn usually grows to a height of 8 to 15 feet. The chaff on the seeds is of a tan color. The brush of this variety is ready to harvest about 90 to 115 days after planting, depending upon the season and the date of planting. Evergreen is the most productive variety in humid sections, but it usually produces less good brush than the Black Spanish, Evergreen Dwarf, and Scarborough varieties where moisture is limited.

BLACK SPANISH

The Black Spanish (Black Jap) variety is shorter and earlier than Evergreen and has dark-brown or black chaff on the seeds. It usually grows to a height of 6 to 11 feet and is ready for harvesting 10 days earlier than the Evergreen variety. Black Spanish broomcorn has been grown in this country for more than 25 years. Its origin is not known, although similar varieties have been introduced from Europe and South America. It is now the leading variety of broomcorn in the Washita Valley of Oklahoma and is rapidly replacing the western dwarf varieties in the western district. The Black Spanish variety is favored by growers in the vicinity of Lindsay, Okla., because of its early maturity and good quality of brush. It has a tendency to produce a finer, straighter brush than the Evergreen variety and is said to be somewhat less subject to reddening, consequently bringing a higher price on the market. Black Spanish is usually outyielded by Evergreen (standard) or the western dwarf varieties except under extremely dry or frosty conditions, when its earlier maturity enables it better to escape drought and frost. Its popularity in Oklahoma and other sections of the West is due primarily to quality rather than to yield. In Illinois, Black Spanish is used chiefly for late planting when strains of Evergreen probably would not mature before frost.

CALIFORNIA GOLDEN

California Golden (Aksarben) broomcorn is similar to Black Spanish in height and time of maturity but differs from that variety in having light tan or golden-colored chaff on the seeds. This variety has been known in the United States for about 50 years but is grown rather sparingly now. Its origin is not known, but it appears to be similar to the descriptions of the broomcorn known as York, Mohawk, or Shaker, which was grown formerly in New York. In yield and quality of brush the California Golden has no advantage over Black Spanish.

WESTERN DWARF GROUP

Western dwarf broomcorn usually attains a height of from 4 to 7 feet. It bears a brush from 15 to 24 inches in length which is weakly attached to the stalk and can be "pulled" or "jerked" at harvest time without cutting. The brush is cut occasionally. The weak attachment of the brush to the stalk is caused by the slender and tender character of the lower end of the stem, which is usually only 8 inches or less in length. About one-half or two-thirds of the length of the brush is covered by the boot or upper leaf sheath at harvest. Water and insects often collect within the boots of dwarf varieties and produce a reddening of the brush which is undesirable from the market standpoint.

The chaff on the seeds is sometimes tan but is usually mostly dark red at maturity.

The brush of western dwarf broomcorn is used for making all types of brooms and whisk brooms. This type of broomcorn is grown in the semiarid western district including southern Texas.

Only three distinct varieties of western dwarf broomcorn are grown. These are Evergreen Dwarf (Oklahoma Dwarf, Acme), Scarborough, and Black Spanish Dwarf.

EVERGREEN DWARF

Evergreen Dwarf has been grown in the Southwestern States for at least 50 years, but its origin is still unknown. Oklahoma Dwarf is merely another name for this variety. Acme is a strain practically identical in yield and appearance with the typical Evergreen Dwarf. It was originated by the United States

Department of Agriculture by selection from a mixed lot of broomcorn grown at Channing, Tex., in 1906 and was distributed about 1915. The Acme broomcorn, therefore, is merely a pure uniform lot of Evergreen Dwarf. A field of Acme broomcorn is shown in Figure 1.

The Evergreen Dwarf variety usually attains a height of 4 to 7 feet and matures in about the same period as the standard Evergreen or slightly earlier. The brush is nearly as long as that of standard Evergreen when grown under the same conditions and is frequently longer than that of the Black Spanish variety. The chaff on the seeds is mostly red at maturity. The brush is equal in quality to standard brush when properly harvested and cured if it is not discolored before harvest and has not been stunted by drought.

Evergreen Dwarf was the leading variety of broomcorn in the western district until recently. It usually outyields the standard Evergreen under conditions of limited moisture.



FIGURE 1.—A field of Acme broomcorn

SCARBOROUGH

Scarborough broomcorn was originated in Texas County, Okla., in 1910, by a farmer named Scarborough, who selected a promising plant in his broomcorn field. It is now extensively grown throughout the western broomcorn district, where it has largely replaced Evergreen Dwarf. Much of the Scarborough now grown is mixed with Evergreen Dwarf. The Scarborough variety is later, slightly taller, and has somewhat longer brush and less reddened chaff on the seeds than Evergreen Dwarf. It differs from other varieties chiefly in bearing fewer seeds, with most of the seeds borne near the tip of the brush, where they are easily removed in threshing. The many fine seed branches near the tip make the Scarborough brush valuable for the hurl or outside of brooms. This class of brush usually is in good demand.

A comparison of the brush of Evergreen Dwarf (Acme) and Scarborough broomcorn is shown in Figure 2.

BLACK SPANISH DWARF

The Black Spanish Dwarf variety was originated by H. Z. O'Hair, of the Grand Prairie Seed Farm, Bushton, Ill. It is a selection from a cross between Black Spanish and Scarborough and was distributed about 1927. Black Spanish Dwarf is similar to the early standard variety, Black Spanish, in time of maturity, color of chaff, and type of brush, but has the height of stalk and weak stem attachment of the Scarborough parent.

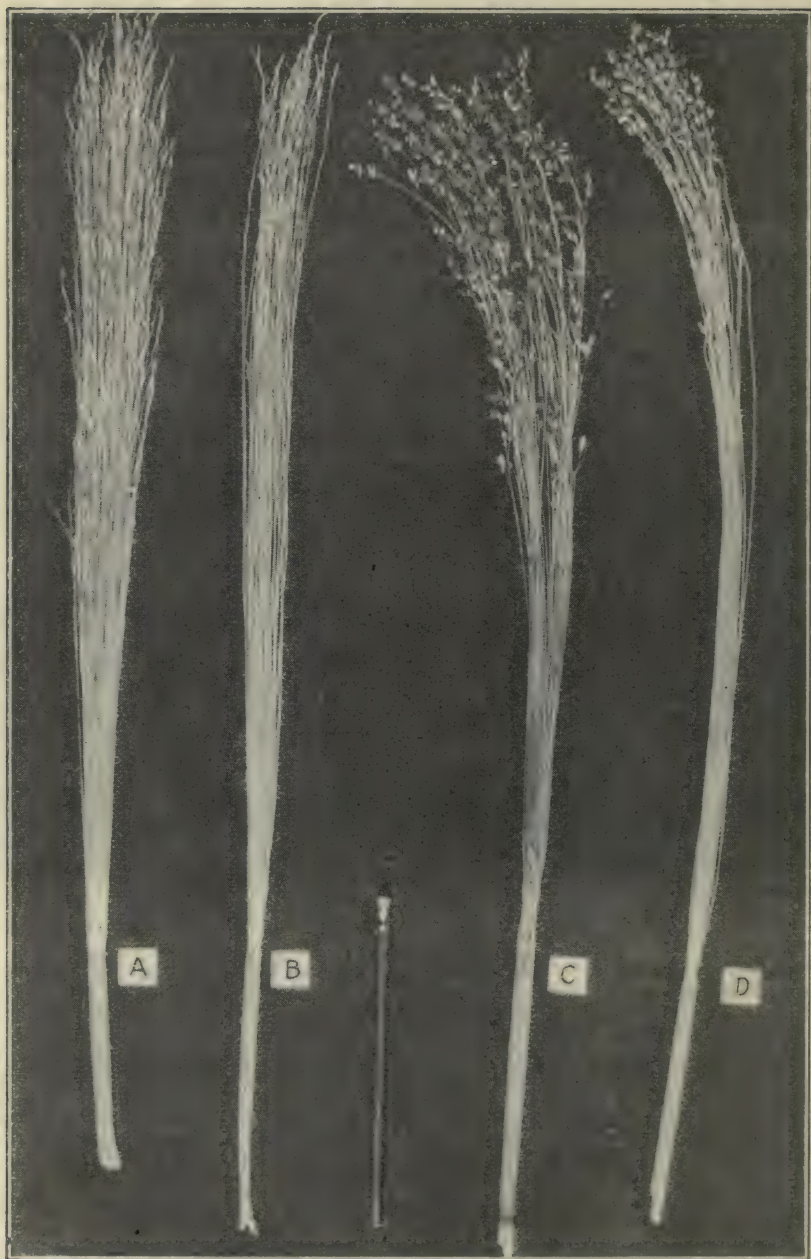


FIGURE 2.—Threshed and unthreshed heads of Acme and Scarborough broomcorn, showing that the seed branches occur nearer the tip of the panicles in Scarborough than in Acme. A and C, Acme; B and D, Scarborough

WHISK DWARF TYPE

Whisk dwarf broomcorn usually grows to a height of 2½ to 4 feet and produces a fine slender brush about 12 to 18 inches in length. The stem is easily detached from the stalk because of several creases or constrictions near the bottom where it joins the stalk. Whisk dwarf broom corn is harvested by pulling or jerking. The stem is short, and three-fourths or more of the length of the brush is covered by the boot.

Whisk dwarf brush is used for making whisk brooms and occasionally for the insides of floor brooms.

JAPANESE DWARF

Only one variety of the whisk dwarf type of broom corn is grown in this country. It is known as Japanese or "Jap" Dwarf, Sterling Dwarf, and Whisk Dwarf. It has been known for more than 70 years but has never been grown extensively, and now its cultivation has been almost discontinued. Its origin is not known, and samples of it have not been obtained from Europe. Japanese Dwarf matures about 10 days earlier than the Evergreen variety and is about as early as Black Spanish. The chaff on the seeds is usually dark red.

The Japanese Dwarf variety produces short, fine brush, well suited for making small whisk brooms, but it yields less and the brush is reddened more frequently than that of other types of broomcorn. Most of the whisk brooms are now made from the brush of other varieties.

SOURCE OF SEED SUPPLY

Broomcorn seed is obtained from three common sources—seed dealers, neighbors, and the home farm. Most of the seed is obtained from dealers, some of whom are also broomcorn-seed growers. Less than a dozen seed growers in Illinois supply practically all of the seed that is sown in that State and in the Lindsay district of Oklahoma. These growers also supply dealers and growers in many other sections. There are a few seed growers in the western district. The regular broomcorn-seed growers usually supply high-grade seed. Particular attention is paid to keeping the crop pure and free from smut.

When grown for seed, the broomcorn is left in the field until the seed is mature and then harvested in the regular manner. The brush is cured in the shed with the seed on. When sufficiently dry, the crop is threshed and the brush baled and saved for market. Such brush, of course, is overripe and reddened and usually sells for about half the price of brush harvested at the proper time. Mature broomcorn except the Scarborough variety usually yields about 3 to 5 bushels of seed per 100 pounds of brush. When the brush yield is 600 pounds per acre, 18 to 30 bushels of seed may be expected if the crop is allowed to mature. An acre of broomcorn yielding 25 bushels of seed will produce enough for planting 500 acres at the rate of 20 acres per bushel. It is thus possible for a comparatively few growers to supply all the demand for broomcorn seed in this country.

In the western district less attention usually is devoted to securing a high quality of seed. Some of the growers use seed supplied by regular seed growers in Illinois or Oklahoma, but many others obtain seed from a neighbor or from their own seed piles. Much of the seed sold by neighbors is simply taken from the seed piles left after threshing the brush. In the western district where the brush is threshed after curing, harvesting frequently is not completed until the seed is practi-

cally mature. Only part of the seed thus obtained is immature. By recleaning the seed with a fanning mill most of the light immature seeds are blown out and the heavier seed is of fair quality for planting. Seed from this source may not always germinate very well and is more likely to be mixed with hybrids of other sorghums and to be contaminated with smut than seed obtained from the regular seed growers. Frequently the grower who saves seed in the above manner is one who had obtained his seed from a regular grower the previous year.

Some growers use seed obtained from the crooked brush left in the field at harvest time. The "crooks" are not considered worth harvesting for brush, so they are left on the stalks. By leaving the crooked brush until the seed is mature a supply of seed which germinates well can be obtained. Some objection has been raised to this method of obtaining seed in the belief that the resulting crop will contain a high percentage of crooked brush. If the original seed was of a pure lot and the crooked brush is the result of environment rather than of being inherent in the variety, the seed from the crooks is just as good as that from other sources. Nevertheless, the regular practice of saving seed from crooks is not recommended.

Unless the crop from which the seed is obtained is known to be free from smut, the seed always should be treated before planting. A complete discussion of the methods of seed treatment is given later under "Diseases."

CROP ROTATIONS

Broomcorn occupies about the same position in the rotation as other tilled crops, such as corn, cotton, and grain sorghum, which follow small grain or a sod crop whenever possible. Frequently broomcorn is grown directly after other tilled crops, including broomcorn itself. In the Lindsay district of Oklahoma, where cotton is the predominating crop, broomcorn usually is grown alternately with cotton, but often follows another crop of broomcorn, or corn, wheat, or oats.

In the western district broomcorn usually follows broomcorn, grain sorghums, or corn. Occasionally it is planted on land that has produced winter wheat the previous season, and when winter wheat is destroyed by winterkilling or soil blowing the wheatland is listed or disked in the spring and seeded to grain sorghums and broomcorn.

In Illinois broomcorn usually is grown in the rotation following corn, wheat, or oats, except where it follows broomcorn. Winter wheat occasionally winterkills, and when this occurs part of the land may be planted to broomcorn in the spring.

Sorghums usually exert a somewhat deleterious effect on crops immediately following them, but this is less pronounced after broomcorn than after other sorghums, partly because the crop is removed from the land earlier. Broomcorn can be followed with winter wheat more readily than can corn or cotton, because the crop is removed in time to prepare the land for fall seeding.

METHOD OF GROWING

Previous to harvest time the growing of broomcorn is very similar to that of other tilled crops, such as corn, grain sorghums, and cotton. The soil preparation, planting, and cultivation all are much the same for those crops in any locality, with a few exceptions. Broomcorn is harvested earlier and often does not need as many cultivations as corn and cotton. It usually does not require any thinning or as

much hoeing as cotton needs, but replanting is more frequent than with corn or cotton.

Beginning with harvest the methods employed and the labor and expenses required for broomcorn differ widely from those of other crops.

SEED-BED PREPARATION

The land on which broomcorn is to be planted often is not worked until some time in the spring, although fall plowing frequently is practiced. In the Washita Valley of Oklahoma the land for broomcorn usually is plowed with a horse-drawn gang or sulky plow, but some of the land is listed instead of being plowed. The plowed land is disked and harrowed in preparation for planting. The listed land is relisted or the ridges broken previous to planting.

In the western district, where grain sorghum is the leading crop, most of the land is prepared by listing in the spring. Frequently the land is disked before being listed. Disking before listing is almost necessary if stalks of sorghum, broomcorn, or corn have been left on the land or if a heavy growth of weeds has started. This disking results in a better seed bed and helps to control weeds. After listing, the ground is sometimes worked with a "ridge buster," but usually it is listed a second time. In the second listing the ridges are split, and the broomcorn usually is sown at this time with a planting device attached to the lister.

In east-central Illinois much of the land is plowed with a tractor gang plow, the 2-plow tractor being the most popular size. If broomcorn follows corn which has been husked from the standing stalks, the stalks usually are broken or disked before the land is plowed. If broomcorn follows broomcorn, the stalks are either burned, cut up, or broken down before plowing, or else they are plowed under directly. After plowing, the land is double-disked and harrowed. Much of the disking in Illinois is done with a tractor-drawn tandem disk. If the tractor has sufficient power, a harrow is attached behind the disk, and the land is gone over only once.

PLANTING

Broomcorn may be planted with any corn or cotton planter or with a lister planter by using special broomcorn or sorghum plates. Broomcorn plates can be purchased or can be made by boring holes three-sixteenths or one-fourth of an inch in diameter in blank plates. All of the planting in Illinois and part of that in other sections is done with the 2-row corn planter. In the western district a 2-row or 1-row lister planter usually is used for planting broomcorn.

DATES OF PLANTING

Broomcorn is planted at any time between April 1 and July 1, but mostly between May 1 and June 15. Most of the planting is done in April in the Lindsay district, in May in Illinois, and in June in Kansas. The earlier the crop is sown the earlier it will be ready for harvest, but since the early-sown crop requires a longer period to reach maturity, the difference between the harvest periods will be much less than that between the planting periods. Sieglinger in his broomcorn experiments at the United States Dry-Land Field Station at Woodward, Okla., has shown that broomcorn planted about June 15 produces more and better brush than that planted earlier. Similar experiments made by the New Mexico Agricultural Experiment

Station at the United States Dry-Land Field Station at Tucumcari, N. Mex., show that June 15 is a good time to plant there also. Broomcorn planted about June 1 frequently has been caught by a drought during the critical period for brush development. Planting about May 15 also has produced better brush at Tucumcari than planting about June 1. Experiments at other stations in the western district favor the planting of broomcorn in June.

The experience of farmers also has shown that broomcorn makes the best and most rapid growth from comparatively late seeding, after the soil has warmed up well.

Many growers sow at least a part of their broomcorn earlier than is desirable for the best development of the crop in order to be able to complete the harvesting while labor is more abundant and cheaper than after cotton picking or corn husking begins. The sowing of broomcorn at different dates makes possible the obtaining of labor for harvest at the proper time. If all broomcorn reached maturity at approximately the same time, the labor supply in a locality might be insufficient to complete harvesting within the required time. It also would be difficult to obtain transient labor for such a short period. Many growers make two or three plantings of broomcorn in order to avoid having the entire crop reach maturity at the same time. If there is an interval of 10 days or more between the harvest of different lots of broomcorn on the same farm it is possible to cure the two crops in the same shed, thus doubling the capacity of the shed. Where the labor supply at harvest time is sufficient, planting from about June 1 to June 15 or 20 is advisable, at least in the western districts.

Early planting frequently results in an unsatisfactory stand, and the crop must be replanted. Some growers, knowing that good brush will be produced only from a good stand, replant twice if necessary.

The lister planter drops the seed at the bottom of a furrow, where the soil usually is much colder than nearer the surface. This cold soil hinders germination and frequently prevents a good stand. Heavy dashing rains shortly after seeding often injure the stand of broomcorn planted in lister furrows by washing dirt into the furrows. Water running down the furrows also will wash out the seeds on the steep slopes and bury them too deep in soil at the bottom of the slopes. The failure to get stands and the retarded growth of broomcorn sown in lister furrows make the yields from this method lower than from broomcorn planted with a corn planter on plowed ("flat broke") land, but the lister method is more economical of labor.

RATE OF PLANTING

The rate of planting is of extreme importance in securing a good quality of broomcorn. If the stand is too thick, the brush will be short and "spiky," and if too thin it will be too long, coarse, and crooked. The stand should be uniform, and good clean seed will aid in securing uniformity.

In the humid broomcorn sections, comprising east-central Illinois and the Lindsay district in Oklahoma, the broomcorn plants should be spaced rather thickly, a plant about every $2\frac{1}{2}$ to 4 inches (usually about 3 inches) apart in the row being considered desirable. About 60 to 75 plants per rod is considered a good stand. To obtain such

a stand the seed should be planted at the rate of about 70 to 100 seeds per rod. Some growers plant more than 100 seeds per rod when planting is done early with a lister. The seed germinates best in warm soil, and late planting need not be quite so thick as early planting.

In the western district, where the moisture supply is likely to be limited, a thinner spacing is desirable. Results at the United States Dry-Land Field Station at Woodward, Okla., have shown that a spacing of 6 to 9 inches between plants (25 to 35 plants per rod) produces the highest yield and quality of brush of western dwarf broomcorn on the average. At the Tucumcari, N. Mex., station the 6-inch spacing produced more marketable brush than wider spacings. At Amarillo, Tex., a spacing of 6 to 8 inches resulted in more brush than the thicker or thinner spacings. Standard broomcorn suckers less and should be planted slightly thicker than the western dwarf varieties. To obtain a stand of standard broomcorn in the western district, the seed is planted at the rate of about 40 to 60 seeds per rod. From 40 to 50 seeds of dwarf varieties per rod are sufficient. The quantity of seed required usually varies from 2 to 3 pounds per acre. A bushel of seed, weighing 48 pounds, will thus be sufficient for 16 to 24 acres. A few growers plant more heavily than this, especially when planting early with a lister planter; and a few growers in the drier sections plant less than 2 pounds per acre. About 24,000 to 30,000 broomcorn seeds ordinarily weigh 1 pound.

Occasionally broomcorn is planted in hills instead of drills, but this practice is becoming less frequent. Experiments at the field station at Woodward, Okla., show that the yield and quality of brush from hill and drill planting is nearly the same when the number of plants per rod is the same. Planting in hills is slower and has no advantage except perhaps in enabling better weed control.

Most broomcorn is grown in rows 3 to 4 feet apart, but some growers in the western district space the rows double the usual distance, or 6 to 8 feet apart. Experiments at Woodward, Okla., show that the yields of brush are considerably lower from the wide spacing.

CULTIVATION

The germination of broomcorn is rather slow except in warm soil, and the plants are rather delicate and grow slowly at first. As soon as the plants are large enough, the field should be cultivated promptly in order to destroy weeds. As a rule, ample tillage before the crop is planted will save considerable later cultivation to control weeds. The number of cultivations to be given broomcorn depends upon the amount of weed growth. Under humid conditions three to five cultivations are usually sufficient, and in the drier western districts the crop is usually cultivated only two or three times. The tillage implements are the same as those used for cultivating corn, cotton, and grain sorghums. In the Lindsay district the riding cultivator is commonly used for cultivating. The broomcorn field sometimes is harrowed just as the plants are coming through the ground.

The listed broomcorn is commonly worked once with a 1-row lister cultivator. This is a narrow sled equipped with disks and is locally known as a go-devil. It is followed by two or three cultivations with a 1-row, 2-horse cultivator. In the western district, where nearly all of the broomcorn is planted with a lister, it ordinarily is cultivated

twice with a 2-row lister cultivator, usually referred to as a "curler." In the first cultivation the dirt is thrown out of the furrow, and in the second it is thrown in, to bury weeds in the furrow, kill the weeds on the ridge, and level the ridges. Occasionally a single-row go-devil is used, and sometimes a homemade 2-row weeder known as a knife sled is substituted for the curler. Occasionally a harrow is also used to kill the weeds on the ridges and to bury the small weeds at the bottom of the furrow with dirt which is dragged in.

Broomcorn requires about the same number of cultivations as the grain sorghums, but owing to its being harvested earlier it frequently is cultivated somewhat less than cotton or corn.

HARVESTING

Broomcorn is harvested either by cutting or pulling, usually depending upon whether standard or dwarf broomcorn is grown.

A vast quantity of hand labor is required in harvesting and handling broomcorn. About 10 to 14 days of man labor are required to harvest, cure, thresh, and bale a ton of cured brush. A ton of cured brush contains about 40,000 to 70,000 heads, and each brush or head must be cut or pulled separately by hand. In all subsequent operations the brush is handled in small handfuls or armfuls, and care should be used to avoid tangling the fibers. The necessity of doing the work promptly requires the use of large crews. Many growers use 30 to 40 or more men for harvesting and threshing their crop.

Considerable broomcorn harvesting is done by family and exchange labor in the western district, where harvesting is often not completed promptly. Exchanging labor at harvest time also is practiced by small growers of broomcorn in other sections, and baling crews frequently are made up largely of neighboring farmers. Some growers hire their harvesting, threshing, and baling done on shares or on contract at a stated amount per ton or per acre.

Broomcorn brush turns from pale yellow to green before maturity, and it should not be harvested until the entire brush is green from the tip down to the knuckle. If harvested while the lower ends of the fibers are still yellow, they will be weak and flabby at the bottom. The seeds are about in the milk stage when the brush is ready to harvest. About four or five days after the proper harvesting stage is reached the brush begins to get overripe and starts reddening, and the seeds become firmly attached to the branches. The brush does not increase in weight after the seeds reach the milk stage, all of the later growth going into the seeds.

Broomcorn harvest begins in southern Texas in June and in Oklahoma in July. The harvesting is not completed in the western district until October. Most of the broomcorn in the United States is harvested during August and September.

HARVESTING STANDARD BROOMCORN

Standard broomcorn is nearly always cut from the stalk. Most of the crop is "tabled" or "broken" before it is cut, but some of it is harvested with a corn binder. Tabling or breaking consists in walking between two rows of broomcorn and breaking or bending the stalks diagonally across each other, forming a so-called table of the two rows, with the heads extending out beyond the rows forming the

edges of the table. The table is formed at a height of about $2\frac{1}{2}$ to 3 feet. Usually the tabler walks backward, facing the table as it is formed, but sometimes he walks forward and breaks the stalks behind him. Ordinarily the harvester cuts the brush from the stalks immediately after tabling two rows across the field. (Fig. 3.) Cutting requires two or three times as long as tabling. The cutting is done with a special broomcorn knife. (Fig. 4.) The harvester grasps the brush in one hand and pulls the stem against the blade of the knife at the point on the stem where it is to be cut. (Fig. 5.) By pulling the brush against the knife blade and exerting an outward pull at the same time the brush with its handle or stem can be withdrawn without cutting entirely through the boot. The boot must be



FIGURE 3.—Field of broomcorn, partly tabled, showing the harvested heads lying in piles on the table

pulled from the stem at the time of cutting if it is cut through accidentally. As soon as a handful of brush is gathered it is thrown on the table in small bunches. These bunches, which are of convenient armfuls for loading on a wagon, are placed only on alternate tables. The table on which the brush is piled is referred to as a "lay-on," and the other on which no brush is laid is called a "lay-off."

One man can table and cut an acre of broomcorn in about 15 to 25 hours. Rapid, experienced men when paid by the acre or by the table harvest from three to four tables, or three-fifths to four-fifths of an acre, in a day. (A table in Illinois consists of two rows 80 rods long, or about one-fifth of an acre.) Inexperienced men and transient hands paid by the hour usually harvest about two-fifths of an acre per day on the average. An average day hand thus requires about seven to nine days to harvest a ton of cured brush from 4 acres. The better the yield the shorter the time required to harvest a ton of brush, as it takes only a little longer to harvest an acre of high-yield-

ing broomcorn than it does to harvest a poor crop. Considerably more time is required to harvest a crop of broomcorn containing much defective brush than a crop which is uniformly good. An efficient

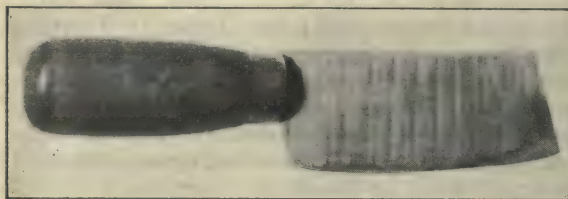


FIGURE 4.—Knife used for cutting broomcorn brush from the stalk

hand may harvest a ton of good high-yielding brush in three or four days.

If the crop is lodged, the labor of harvesting is practically doubled. The cost of harvesting lodged broomcorn is

so high that frequently it is left unharvested, especially on farms rented for a share of the crop with the tenant paying for the harvesting.

The brush is left on the table 24 hours or less, usually being hauled soon after it is cut. In

case of rain the piles are turned over on the table as soon as the tops of the piles are dry. In hauling, a wagon is driven over the lay-off table and a man on each side of the wagon loads the brush from the two adjoining lay-on tables. The brush is piled upon the wagon in two tiers with the seed ends outward. (Fig. 6.) Dump racks are used for hauling the green brush to the shed. The racks used in Illinois (fig. 7) cost about \$25 each, but the simple racks used in Oklahoma with the load balanced on the rear axle of the wagon and the front end held down with a stay chain (fig. 8) cost only about \$15.

One ton of green brush is equivalent to about 500 pounds of cured brush with the seed removed. Two men and a team haul about six to nine loads of green brush per day. The brush is hauled to the front of the curing shed and slipped off to the ground in piles. (Fig. 8.) As soon as a few loads have accumulated, the brush is threshed



FIGURE 5.—Method of cutting broomcorn

and placed on the slats within the shed to cure. Curing requires about 10 days to three weeks, depending upon the weather, the dryness of the brush, and the thickness of the layer placed on the slats.

In the western district much of the standard broomcorn is not



FIGURE 6.—A load of green broomcorn brush en route to the curing shed

handled in the manner described above. If the crop is less than about 9 feet high it does not form a good table, and frequently the stalks are simply broken over in the same row instead of being tabled. By this method the harvester walks forward, breaking the stalks

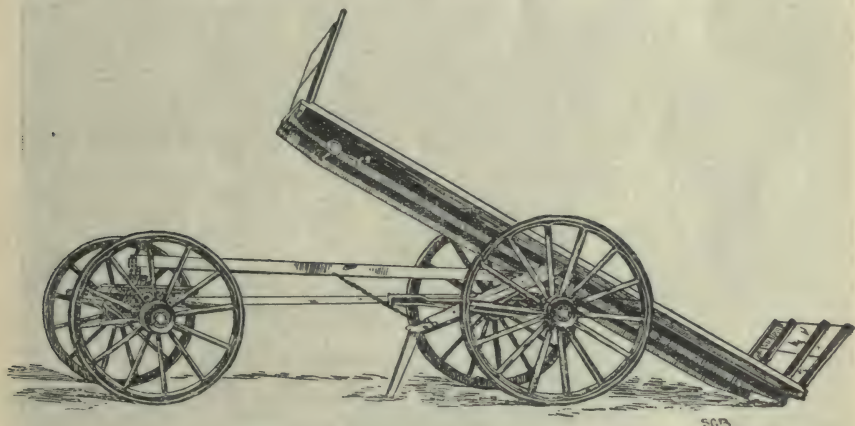


FIGURE 7.—Broomcorn dump rack used in Illinois

forward, and when the end of the row is reached he turns around and starts cutting back on the same row with the brush pointing toward him. The stalks are broken at a point which leaves the hanging brush about waist high. If the stalks are not more than 7 feet tall the brush sometimes is cut from the standing stalk without breaking.

When the crop is not tabled the bunches of brush either are thrown on the ground or upon stalks which have been broken over, or else



FIGURE 8.—Unloading brush with the type of dump rack used in Oklahoma

they are placed between two stalks in a row (fig. 9) so as to hold the brush up off the ground. In fields yielding 300 to 400 pounds per acre



FIGURE 9.—Bunches of brush placed between dwarf broomcorn stalks to cure

an average hand can break and cut a ton of cured brush in about seven days. In the western district, where these latter methods of harvesting are practiced, the brush often remains in the field for

several days and sometimes two weeks before it is hauled. The curing is completed in ricks. Ordinary nondumping racks (fig. 10) costing about \$15 are used for hauling brush to the rick. The crop is left in the ricks until entirely dry, when it is threshed and baled in one operation.

Occasionally in the western district broomcorn is cut with a row binder (corn binder) and allowed to cure in the shock. The brush is cut from the stalk later by hand. Brush harvested with a binder seldom is of the best quality because it is bleached. This method of harvesting is practiced only in emergencies, either when labor is insufficient to harvest the brush while in proper condition or in order to avoid hiring labor. By this method the stalks can be bound and shocked and the brush cut later by the farmer or members of his family, thus avoiding a heavy cash expense for harvest labor.

HARVESTING DWARF BROOMCORN

Dwarf broomcorn is pulled or jerked from the standing stalk instead of being cut. The operator grasps the top or "flag" leaf in



FIGURE 10.—Rack used for hauling broomcorn in Kansas

one hand and the ends of the brush in the other hand and gives a quick pull outward with both hands and a jerk upward on the brush. This snaps off the brush stem where it joins the stalk at the upper joint. As soon as a handful of brush is gathered it is thrown in a pile or is placed between stalks (fig. 9), as mentioned under the discussion of harvesting standard broomcorn. The subsequent curing and handling of the dwarf brush is identical with that of standard brush in the western broomcorn district. Many growers go through their fields of dwarf broomcorn a second and occasionally a third time to pull the brush which was immature at the time of the first harvest.

A man can pull about a bale (one-sixth of a ton) of cured brush per day in dwarf broomcorn yielding one bale per acre or thereabout. Average transient hands pull slightly less than a bale per day, but good workers frequently pull as much as 500 pounds in 10 hours in good fields. Pulling is more rapid than breaking and cutting, because no time is lost in determining where the stem should be cut and only one operation is necessary.

THRESHING

The operation of threshing broomcorn brush often is referred to as scraping or seeding. Threshing is a disagreeable task, because the fine hairs which are knocked off the chaff are very irritating to the eyes and skin. Many men refuse to work with broomcorn, because of the discomforts of "broomcorn itch."

Broomcorn may be threshed either before or after curing. It is of better quality when threshed before curing, because fewer of the fine branches are knocked off by the thresher when the brush is moist and flexible. All of the broomcorn grown in Illinois and in the Lindsay district of Oklahoma except that saved for seed is threshed before curing. In the western district most of the brush is threshed after curing and is baled immediately after threshing. All brush that is threshed before curing is cured in sheds or on racks, and some brush is shed cured before threshing.

The power threshing machines have two cylinders, one above the other, rotating in opposite directions. The brush is carried past the

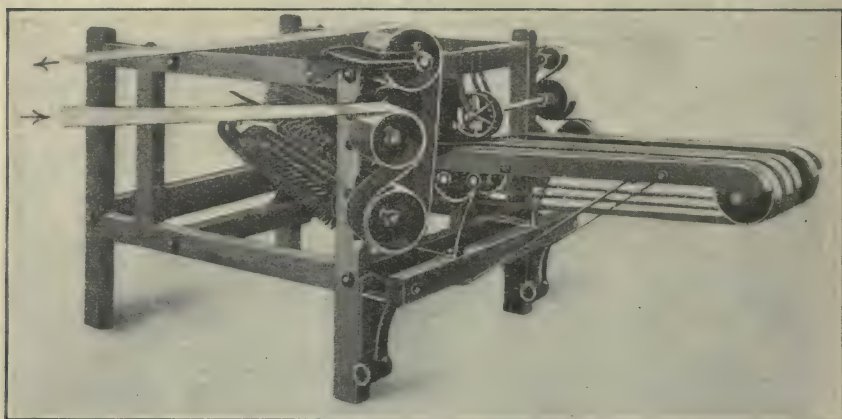


FIGURE 11.—Side view of a self-fed broomcorn thresher

cylinders by a toothed chain which runs at an angle with the cylinders. The seeds at the tip of the brush are knocked off first, but as the brush is carried toward the far ends of the cylinders the chain runs nearer the cylinders and the remaining seeds are removed.

Most of the threshing is done with large self-fed power threshers (fig. 11), but a few growers use small hand-fed machines (fig. 12). The large outfits require a crew of 15 to 30 men for the entire operation. One man looks after the thresher and engine; another feeds the brush into the machine; and from 5 to 10 men untangle the brush, even it up, slide it toward the thresher, and sort out the poor brush. The remainder of the crew carry the brush in armfuls from the pile to the table on which it is evend, or carry the brush from the thresher and place it on the shelves in the shed. The placing of the brush on the shelves is a considerable task because the slats must be put in place as the brush is brought in, and each pair of slats will hold only about one large or two small armfuls of brush. An average crew of 26 men will thresh and shed about 15 to 18 tons of cured brush per 10-hour day. Smaller crews sometimes can thresh and shed nearly as much brush as the larger crews, but they are likely to do poorer work.

It is important that practically all the seed be removed from the brush, and this can not be done unless it is evened at the butts or tips and laid straight before being fed into the thresher. The feeder chain should engage the brush just above the knuckle. Any seed to be removed should not be nearer to the chain than 4 inches. Feeding should be uniform with the brush in a layer about 2 inches thick.

The proper speed for the thresher cylinders is about 1,200 to 1,500 revolutions per minute. Slow cylinders will not thresh clean, and fast cylinders will break off too many fine branches or seed fibers.

Most of the broomcorn threshers are driven by 2-plow size tractors, which are also used to haul the machine from one farm to another. Some operators have mounted the threshers on autotrucks, and the motor of the truck furnishes the power for driving the thresher. The large threshers when new cost about \$450 delivered. The most expen-

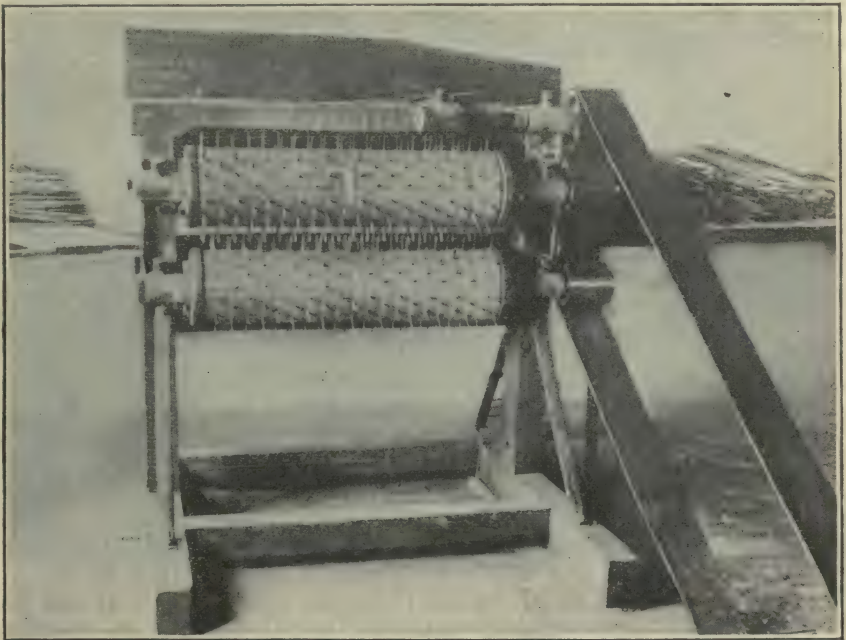


FIGURE 12.—Rear view of a hand-fed broomcorn thresher

sive item of replacement is the feeder chain, which costs about \$30 or more.

The small hand-fed machines have either one or two cylinders. They can be operated by small crews of from 1 to 8 or 10 men. A small gasoline engine will furnish sufficient power for one of these threshers. Better threshing is possible with hand-fed machines than with power machines if sufficient care is taken.

The usual procedure in harvesting and threshing broomcorn is to start the entire crew to tabling and cutting brush in the field. After the first tables have been cut, from 2 to 4 teams with 2 men to each wagon are set to hauling brush. The brush is hauled and dumped in front of the shed. The custom thresher comes to the farm during the afternoon or evening, or perhaps the following morning, and the entire crew, except the haulers, is called in from the field to assist with

the threshing. The hauling continues until all or most of the harvested brush has been brought from the field and threshed. When the threshing is completed the men resume the harvesting until the thresher returns, perhaps on the following day.

Where the threshing is done from the rick a smaller crew is required for the threshing operation than where the threshed brush must be placed in the shed to cure. Rick-threshed brush is nearly always baled immediately from the thresher. (Fig. 13.) A crew of about 20 men is required for threshing and baling brush from the rick. Such a crew consists of 1 man to run the machinery, another to place the brush inside the baler, about 7 to 8 men to "butt up" the brush and feed the brush to the thresher, about 5 or 6 to carry brush from the thresher to the baler and assist in pressing and tying the bale, and about 4 men to carry brush from the ricks to the feeding table. Such a crew will thresh and bale about 8 to 10 tons of brush per day.



FIGURE 13.—Threshing and baling broomcorn from the rick

CURING

Threshed green brush placed in the shed loses about half its weight in the form of water which is evaporated before the brush is dry enough for baling. This requires from 10 days to two weeks under ordinary conditions, and a longer period if the weather is damp. The longer the brush is left in the field, the more quickly it can be cured in the shed. Brush left on the table in the field more than 24 hours, however, is likely to become bleached. The brush is usually placed on the slats at a depth of 2 to 3 inches, depending upon the amount of moisture that it contains. (Fig. 14.) If the brush is piled too thickly it may become "shelf burnt" or discolored on account of heating, together with some reddening. When the brush starts to heat it should be reshelved to prevent further damage.

Sheds are usually built in stalls or bents $7\frac{1}{2}$ feet wide, 10 feet and sometimes more in height, and any convenient length. The cleats on the sides of the stalls consist of 1 by 4 inch boards spaced 2 inches apart. The slats are laid across these cleats when filling the shed with brush. The slats are 1 by 2 inch boards 8 feet long. This length permits an overlapping of 3 inches at each end of the slat. The 4-inch cleats spaced 2 inches apart permit a layer of brush every 6 inches. When the brush is piled in 3-inch layers there is an air space of 3 inches between each layer. Two slats are necessary to support each layer of brush in a tier. These slats are placed about 16 inches apart.

The outside posts of the shed usually are 6 by 6 inch timbers or round posts 6 to 9 inches in diameter and 10 feet long. In well-built sheds these posts are creosoted and set on a concrete base. The inside posts usually are of 2 by 4 inch or 2 by 6 inch pieces, long enough to reach to the rafters. The roof usually is made of corrugated iron, but shingles and prepared roofing also are used. The roof should extend 2 to 4 feet beyond the plate. The ends of the gables are boarded with sheathing, but the ends and sides of the shed below the plate usually are left open. No braces are used except on the rafters and between the posts and the plate. The cleats serve as braces for the posts. Frequently several cleats are nailed to the inside posts



FIGURE 14.—Shed filled with brush in process of curing

above the level of the plate, to permit the use of the space next to the roof for curing brush.

Sheds are built with the stalls either crosswise (fig. 15) or lengthwise (fig. 16). Most of the sheds in Oklahoma have cross stalls 24 feet in length, but in Illinois the lengthwise stalls are more common.

A stall $7\frac{1}{2}$ feet wide, 24 feet long, and 10 feet (or 20 cleats) high will hold about $1\frac{1}{2}$ tons of cured brush piled 2 to 3 inches deep. Such a stall will hold about 10 tiers of brush 20 layers high and will thus require about 400 slats. At this rate about 266 slats are necessary for curing a ton of brush. The slats cost 6 to 10 cents apiece, depending upon the quality and kind of wood. The cost of building an ordinary shed is about \$30 to \$40 for labor and material per ton of capacity, but well-built sheds may cost up to \$60 per ton of capacity. Broomcorn sheds are not commonly used much except for curing the brush and the storage of the bales for a short time before the crop is marketed. (Fig. 17.) They can be used, however, for storing machinery



FIGURE 15.—Broomcorn shed with crosswise stalls



FIGURE 16.—Broomcorn shed with lengthwise stalls



FIGURE 17.—Baled broomcorn stored in a curing shed

and baled hay, and in Illinois most of the better constructed sheds are used also as corncribs.

Bulking of broomcorn brush before baling is practiced to a considerable extent in Illinois, more than half of the growers bulking all or part of their crop. Bulking consists in removing the brush from the slats and piling it in the shed at a depth of 4 to 6 feet. Bulking is done for three reasons: (1) To make shed room available for another cutting of brush; (2) to lessen the drying or shrinkage of the brush before baling; and (3) to reduce the size of crew necessary at baling time. One man can bulk about 2 tons of brush per day. When the bulking is done by the farmer or members of his family, some saving in the expense for hired labor at baling time is effected. If the bulking is done by hired labor, however, the expense is greater than when baling is done directly from the slats, because the total labor is greater when the brush is bulked. About three or four more men are required when baling is done from the slats than when it is done from a bulked



FIGURE 18.—Ricks of broomcorn

pile. These additional men are needed for gathering and carrying the brush from the more or less inaccessible slats and for removing and piling up the slats. If a baler can be secured promptly the brush can be baled as soon as it is dry enough, and further shrinkage thus can be avoided without bulking. Prompt baling permits the use of the shed for a second cutting of brush just as effectively as does bulking, but the latter can be done a few days sooner than baling without the danger of spoiled brush.

The curing of brush in ricks saves considerable labor and expense, but involves a much greater risk from weather. (Fig. 18.) Rick curing is not considered safe except in the semiarid western district. Even in that district, shed curing pays during many seasons. Rick-cured brush is seldom of as high quality as shed-cured brush, because of the greater bleaching and sometimes the discoloration from rain. Under favorable weather conditions, however, rick-cured brush may be of excellent color and appearance, especially if the crop is ricked rather promptly after cutting and the ricks are well built.

The ricks usually are 3 to 5 feet high, about 4 feet wide at the bottom and tapering upward, and are made of any convenient length. The brush is laid in two tiers with the seed ends outward and the butts overlapping in the middle of the rick. The seed ends are on the outside at the ends of the rick also. Well-made ricks should be built up by keeping the middle full of brush laid lengthwise and by careful topping to make them shed water. The top is formed with a single layer of brush. Stalks, straw, or poles laid on the ground will protect the bottom layer of brush. Ricks are usually built in or at the edge of the field on which the broomcorn was grown, but occasionally are built in the barnyard. Two men with a team can haul and rick about $1\frac{1}{2}$ tons of brush per day. The brush is loaded on racks just as in

hauling green brush to the shed, but dump racks are not used. The brush is taken from the racks in armfuls and placed in ricks. Slightly more labor is required for hauling and ricking brush than for simply hauling and dumping on the ground.

BALING

Brush is baled either from the shed or from the rick. When baled from the slats in a shed a crew of about 8 to 15 men is employed. When baling bulked brush about 6 to 10 men are sufficient. A crew of 12 men will bale an average of about 10 tons of brush per day from the slats, and 8



FIGURE 19.—Placing the brush in the baler

or 9 men will bale about the same quantity from a bulked pile. Two horses are needed with the baling outfit to pull the machine from farm to farm, and one of the horses is used to compress the bales.

In baling broomcorn a man stands in the hopper of the baler and receives the armfuls of brush handed to him by other men and places these armfuls in the hopper with the stems outward, butting them as evenly as possible against the ends of the hopper and spreading out the brush. (Fig. 19.) The armfuls of brush are placed at alternate ends of the hopper with the tips of the brush overlapping in the middle. When the hopper is partly full the front gate is closed and the filling continued until the brush reaches the top of the hopper. Then the lid is clamped down, and the brush is pressed into the size of a bale. A horse attached to a sweep pulls a capstan, and a set of levers forces the plunger up from the bottom. (Fig. 20.) The

sweep moves only in a semicircle and is hooked while the front gate of the hopper is opened and the bale tied with five wires. After tying, the sweep is unhooked and let back, and the bale is rolled out and away from the baler.

The wires are tightened by means of a T-shaped device made from about 1½-inch iron pipe. Holes are drilled near the end of the long part of the T, and the end of a wire is inserted in one of these holes after it has been drawn through the loop in the other end of the wire. This device is then turned to wind the wire on the pipe and draw the wire through the loop. When tight the wire is bent sharply through the loop to hold the slack, and the pipe is unwound, and the wires are then twisted around themselves and the slack ends used as crossties. The wire used is No. 9, 10, or 11. It comes in bunches of 125 wires each, weighing about 50 pounds and costing \$2.50 to \$3 a bunch. A



FIGURE 20.—Pressing a bale of broomcorn

bunch is sufficient for 25 bales of broomcorn. Each wire has a loop at one end.

Considerable care is necessary in order to secure uniform and compact bales of brush. A well-made bale of broomcorn is shown in Figure 21. Ragged or uneven bales are unattractive and usually do not bring the best price. Tangled brush can be easily seen in the bale. The bunches of brush must be butted carefully on a flat surface, such as a table, box, or barrel, before they are handed to the man in the baler, and this man also must use considerable care in laying down the brush. Brush with the seed end outward detracts considerably from the appearance of the bale. A bale of brush usually weighs about 300 to 350 pounds, and the extreme variation is from about 200 to 400 pounds or more in weight. Ordinarily about six bales of brush make a ton. The dimensions of the bales are about 26 by 32 by 45 inches.

Where baling is done at the same time as threshing, two balers are sometimes used with one thresher. Brush then can be placed in one baler while the bale is being tied in another. This permits a continuous baling process, whereas with only one baler the bunches of threshed brush must be placed on the ground while a bale is being tied and then picked up again and put into the baler.

An ordinary baler mounted on transport trucks costs about \$250 when new. The iron castings occasionally are broken and must be replaced, and the woodwork requires renewing every few years.

Although most of the baling is done by horsepower, machines are available in which the compressing is done by hand with a crank or lever.

MARKETING

MARKET TYPES OF BRUSH

Broomcorn brush is classified roughly according to the use to which it is to be put. That known as "insides" or "handle corn" is usually short and sometimes rather stemmy and is used for making the inside portion of a broom. Brush called "covers" or "turnovers" usually

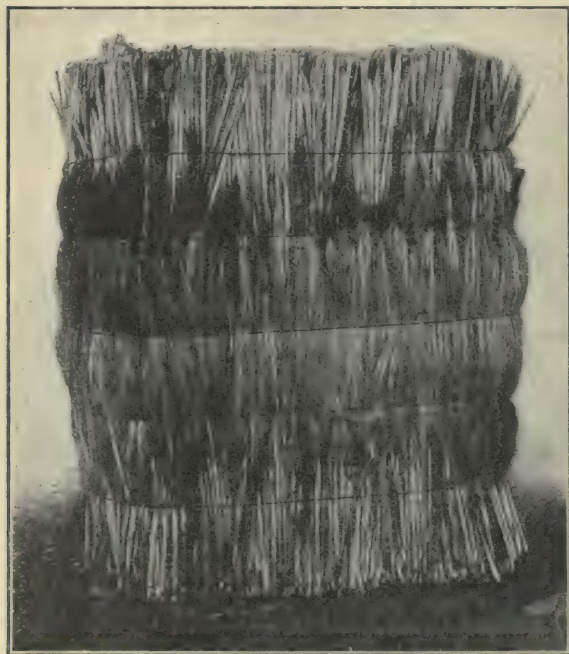


FIGURE 21.—A well-made bale of broomcorn

is somewhat longer and is used for making the shoulders of a broom. The brush used for insides and covers is also known as underwork. "Hurl" is the long, fine brush used for making the outside of a broom. "Self-working" brush is any lot which contains approximately the proportion of insides, covers, and hurl desired for making brooms.

Various types and grades of brooms are made from the different qualities of brush. The best are known as parlor brooms and are made from good, fine brush having plenty of fine

round branches or seed fibers. Other carpet or floor brooms may be made of somewhat coarser brush. Barn brooms and warehouse brooms are made from long, coarse brush which sometimes also is flat or twisted. The coarse brush sells for much less than the finer brush used in making carpet or floor brooms. Whisk brooms are made from the short, fine fibers of the whisk dwarf broomcorn and also from the standard and western dwarf broomcorn brush.

FACTORS DETERMINING QUALITY OF BRUSH

COLOR

The best quality of brush has a bright pea-green color and is free from any discoloration. Brush that is overripe, red, or bleached or whitened from extreme heat before harvesting or from overexposure to the sun does not bring the best price. Much of the brush, especially of the dwarf varieties, contains varying proportions of reddened

fibers. This reddening is due to a coloring material in the broomcorn plants formed whenever the stems, leaves, or heads are injured by insects, mechanical abrasions, excessive moisture, or overmaturity. Broomcorn brush is usually dyed to a uniform green color and bleached with sulphur at the factory just before being made into brooms. The dyeing and bleaching, however, do not eliminate the red color, so red brush is used only in cheap brooms and does not command a high price on the market. Ripe reddened brush is worth about half as much as the same brush harvested at the proper time. Brush sometimes is stained or discolored by mold, exposure to rains, or contact with the ground, or by being "burned" in the shed, rick, or bale. These discolorations affect the market value of the brush, although they can be removed largely by bleaching and dyeing.

FIBER

Other things being equal, brush of medium length brings a higher price than extremely long or short brush unless there is a shortage of the extreme lengths. Brush shorter than 17 inches usually is used for underwork, while that longer than 24 inches either must be used for making up the large barn and warehouse brooms or else must be trimmed and the extra length wasted. Whisk dwarf fiber, however, usually is only 12 to 15 inches long.

The fibers should not be too thick or coarse, as those which are thicker than is desired in a parlor broom bring a lower price because they must be made into cheaper brooms. Fine fibers are one-sixteenth of an inch or less in diameter. Brooms made from coarse fibers do not sweep so cleanly as those from fine ones. Fine branches near the tip of the brush increase the ability of a broom to sweep clean. It is desirable that these branches be near the tip of the brush to be of the most service in sweeping. Good fibers are nearly round, straight, and flexible. All of the fibers should be attached to the stem at approximately the same point, forming a well-defined knuckle.

SEEDING AND BALING

The more thoroughly the brush is threshed the higher the price it will bring. Seed left on the brush is of no value and must be removed at the factory before the broom is completed. The lower price for poorly seeded brush will much more than offset any increased weight due to seed in the brush sold. Well-baled broomcorn brings a higher price than that which is baled in a careless manner and which is likely to go to pieces in handling and shipping. Some growers trim the ends of the stems on the bales to improve the appearance of the bales and to reduce the quantity of stem.

LENGTH OF STEM

The stems of standard broomcorn should be cut to a uniform length of not more than 6 inches to facilitate threshing. The stems are cut off when the brooms are made, except from the part used for insides, and therefore are of no value to the manufacturer.

DEFECTIVE BRUSH

Defective brush consists chiefly of spikes, crooks, and burly, twisted, flat, and stemmy brush. Other defects include bleached, reddened, stained, moldy, burned, wavy, kinky, jointed, and immature brush.

Some of these defects are shown in Figure 22 in comparison with good brush. Brush with serious defects, including crooks, spikes, and badly bleached, reddened, twisted, or curled fibers, should not be harvested



FIGURE 22.—Good and poor heads of dwarf and standard broomcorn: *a*, A good grade of crooked; *b*, high-grade whisk stock; *c*, group of spikes, worthless, but often harvested; *d*, poorly tipped brush showing also a heavy undesirable center stem; *e*, high grades of standard and dwarf, round straight fiber, full tipped with smooth, well-defined knuckles, no center stems; *f*, objectionable early growth but marketable; *g*, worthless curly brush; *x-y-z*, sectional view of brush showing (*x*) stem, (*y*) knuckle, (*z*) fiber

unless the price is sufficiently high to pay for harvesting and sorting the defective material. When the price of good brush is \$250 or more per ton it may pay to harvest the crooks and some of the other seri-

ously defective brush, but all such poor brush should be sorted and baled separately from the better brush.

Spikes, known also as "tree tops," are short heads with the branches coming out all along the main stem, resembling a head of sorghum, and are practically valueless because they do not contain well-defined fibers.

Spikes are produced when the stand is too thick, or the moisture supply insufficient, or when a severe drought occurs while the brush is developing. Spikes also occur in broomcorn that has become crossed with other sorghums, indicating that good seed is important. The branch heads produced on a stalk after the brush has been harvested are always spikes.

Crooks are heads that come out of the boot too rapidly and bend over before the brush has stiffened. After the fiber becomes stiff the crooks can not be straightened. Crooks are chiefly the result of too thin spacing or too much moisture at the time the crop is heading. Tall, rank varieties of broomcorn produce more crooks than the shorter and the dwarf varieties. In order to utilize crooks, the brush must be cut off above the crook and therefore is worth only the value of the portion above the crook. At the low prices of 1928, crooks were not worth harvesting.

Burly, curled, and twisted brush is of some value for insides if this curling or twisting is not too extensive. If the curls, twists, or kinks extend throughout the length of the brush, these defective types should not be harvested. Flat brush is the result of using a poor strain of seed, or of the brush growing too rank, because of thin spacing or excessive moisture. Flat brush is suitable only for large, cheap brooms.

Brush frequently contains center stems one-tenth of an inch or more in thickness. Brush with center stems can be used as insides in a broom but not for hurl, and consequently it brings a lower price than brush without this defect.

The Bureau of Agricultural Economics of the United States Department of Agriculture has established standards for the grading of broomcorn, and some brush is now being marketed on the basis of the United States grades. These standards specify the quantities of brush having various lengths, thicknesses, and defects which may be permitted in each grade of hurl or underwork. Crooks and short spikes are not listed as defects in the standards, but the length of brush in crooks is measured only from the bend to the tip, and short spikes are included in dockage.

MARKETS

Broomcorn brush is sold principally to factory representatives or to other buyers in primary or country markets or is shipped to terminal markets. Local factories are of importance to the grower only in sections where broomcorn is produced very sparingly. As a rule local factories furnish an outlet for only a limited quantity of brush. Most of the broomcorn brush is marketed at important shipping points, including Charleston, Mattoon, and Arcola, Ill.; Lindsay, Pauls Valley, Purcell, Chickasha, and Elk City, Okla.; Liberal, Hugoton, Syracuse, and Elkhart, Kans.; Springfield, Colo.; Portales, N. Mex.; and Beeville, Tex. Warehouse facilities are available at most of these markets, but at some western markets the bales of broomcorn are left on the ground in the open until shipped. (Fig. 23.) Broomcorn frequently is hauled considerable distances by autotruck in order to be sold at

the more important markets. The chief terminal market is Wichita, Kans. Considerable quantities of broomcorn purchased at country markets are shipped to the terminal markets and stored in warehouses while awaiting orders from broom factories. These factories are located in all parts of the United States, but most of the brooms are manufactured near the large centers of population. Shipping broomcorn brush for long distances in carload lots is cheaper than shipping the brooms in small quantities.

TIME AND METHOD OF MARKETING

Much of the broomcorn is sold as soon as it is baled, and sometimes before baling. Growers hold their crop only when higher prices are anticipated or when there is difficulty in securing a buyer. Unless forced to sell in order to obtain money, the growers usually await the pleasure of the buyer in coming out and looking at the brush, believing that overanxiety to sell may result in a lower price. When prices

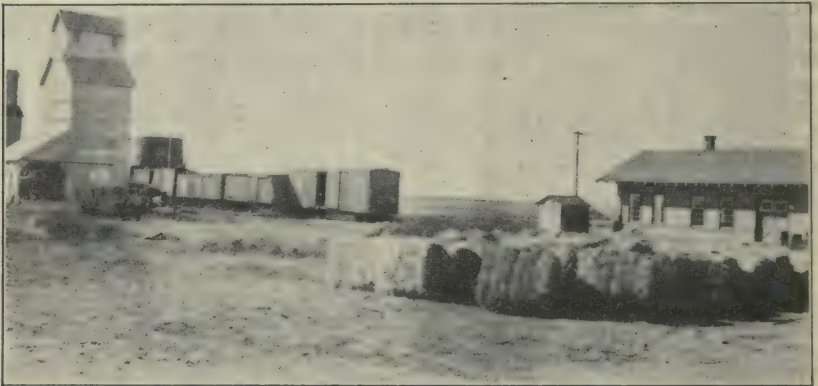


FIGURE 23.—Bales of broomcorn left on the ground in the open, awaiting shipment

seem too low, growers sometimes hold their brush for a year or more before selling, and when the supply of brush is large it must be held or else sold at a low price.

Where brush is rick cured and baled in the open, it should be sold or stored rather promptly, as rains may cause considerable damage to the baled brush. Where the brush is shed cured the bales can be stored in the shed until time for delivery.

The buyers of broomcorn brush usually can be listed under one of the following headings: Local buyer, commission dealer or broker, factory buyer, speculator, or cooperative-marketing association. Local buyers purchase much of the brush that is offered outside of the regular marketing season. These local buyers may be regular broomcorn buyers or may be engaged primarily in some other line of business. Much of the brush is now sold to commission dealers or brokers. These buyers purchase broomcorn on orders from factories and charge their clients a commission. Many brokers maintain warehouses or have storage space available. The brokers usually purchase only brush for which there are orders or a demand.

Large broom factories frequently send out their own buyers during the harvest season and purchase direct from the growers. Factory

buyers visit the same localities as others but are interested only in brush suitable for the types of brooms made by their factory.

Speculators sometimes purchase considerable quantities of brush with the intention of selling it later, frequently at a considerable advance in price. They buy any type of brush on which they think they can make a profit.

Some brush has been marketed through cooperative associations during recent years, but not all of these associations have been successful. Pooling of the crop would be very desirable from the standpoint of the grower if production could be controlled, were it not for the fact that the entire brush requirements could easily be grown by men who are not members of the pool. The comparatively small acreage of broomcorn needed and the large areas in which broomcorn is adapted are effective bars against a monopoly of the crop by the growers in a few sections.

Most of the broomcorn is now sold to buyers who come to the farm. The buyers are able to inspect all of the brush and avoid later misunderstanding in regard to its quality. Buyers usually congregate in a community when the brush is ready for market and buy as much of the crop as can be secured at a satisfactory price. Usually the brush is delivered as soon as it is sold. Many growers exchange work with their neighbors in order to get the crop hauled promptly.

Formerly much of the broomcorn was sold on the street at the marketing points, but at the present time this manner of selling is chiefly confined to growers who have only a few bales to sell. Selling on the street frequently was very unsatisfactory to the growers, because they believed that the buyers took advantage of the fact that a farmer would sell at almost any price rather than haul his brush back to the farm. Frequently when the demands were well supplied it was impossible for a farmer to sell his load of brush on the street until the close of the day and then only at the buyer's price. Strong competitive bidding for brush is likely only when there is a shortage of brush.

The marketing of broomcorn is on a very unsatisfactory basis. There are no definite price quotations such as are reported in the daily papers for most other agricultural commodities. Approximate prices of brush reported by dealers are available in broomcorn trade journals and some local newspapers. These prices are not based on definite grades or qualities of brush, however. Purchases and sales of brush at the country points are made by oral bargaining, which usually consists of a battle of wits.

When the needs of buyers are supplied they are not interested in further purchases except for speculation, because they are not able to dispose of unlimited quantities at terminal markets, as they can some farm commodities.

Most of the brush except that produced on farms within 5 miles of town is now hauled from the farm to the market by autotrucks. (Fig. 24.) From 9 to 12 bales usually make a load for a small or mid-sized truck. Farmers without trucks usually hire their crop hauled unless they are near enough to market to haul two loads a day with a team. The charges for hauling broomcorn vary from \$1.50 a ton for short distances up to \$4 a ton where the haul is 20 to 25 miles. Only six or eight bales can be loaded on an ordinary wagon rack, so that hauling long distances with teams is not economical.

Farmers growing small quantities of broomcorn sometimes manufacture brooms for sale instead of selling the brush. The brooms can be made during spare time in the winter. Equipment for broom making by hand can be secured at a moderate cost, but the more efficient power winding and stitching machines are rather expensive. The economy of making brooms instead of selling brush depends upon the skill of the farmer in making and selling the brooms. Only a small proportion of the broomcorn crop is made into brooms on the farm. About 80 to 100 dozen of ordinary brooms can be made from a ton of brush.

DISPOSAL OF SEED AND STALKS

Where broomcorn brush is harvested promptly and threshed before curing, the seed is so immature and wet as to be practically valueless. It is usually allowed to rot in the pile and later hauled out as manure. In the western district, where the crop is threshed after curing, the seed has some feed value. Seed from brush harvested at the proper time is chaffy and of little value, but the more nearly mature the seed

is when harvested the better it is for feed. Mature broomcorn seed has about the same value as oats for feed. Considerable quantities of broomcorn seed are fed to chickens and frequently to other kinds of livestock. As a rule, however, the livestock are simply allowed to run to the seed pile and eat as much as they want. A few growers reclean the seed and save the



FIGURE 24.—Loading broomcorn on a truck for hauling to market

heavier portion for feed. Estimates of growers show that they consider broomcorn seed worth from nothing to about as much as corn and grain sorghums.

The stalks of standard broomcorn seldom are used except as crop residues which are returned to the soil. Dwarf broomcorn stalks, on the other hand, are regarded of considerable value for pasture where livestock is available. Some farmers who are able to turn in their stock or rent their dwarf broomcorn-stalk pasture consider it worth about \$1 to \$2 an acre, but often there are too few animals to utilize the available feed. The dwarf broomcorn stalks remain green after the brush is removed because the stalks are not broken over during the harvesting operation as in standard broomcorn. Dwarf broomcorn stalks are more leafy than those of standard varieties, and the plants produce more suckers. The western dwarf type of broomcorn also produces more fodder than the early standard sorts in the western district.

Many broomcorn growers in Illinois and in the Lindsay district of Oklahoma burn the broomcorn stalks before plowing the land. If the stalks are thoroughly dry they can be easily burned by setting

fire to the tables. In this way one man is able to burn about 20 acres or more of stalks per day. If the stalks must be cut and raked before burning, about three days' additional labor with a man and team will be required on 20 acres. Many of the growers are able to plow under the stalks directly usually by using a tractor-drawn 18-inch sulky plow. Plowing with this outfit is more tedious than plowing ordinary stubble land with a 2-bottom plow, but in this way a considerable quantity of organic matter can be put into the soil. Stalk cutters or rails, such as are used on cornstalks, sometimes are used to break the broomcorn stalks in the spring.

In recent years a small quantity of broomcorn stalks has been used in the manufacture of paper and other cellulose products, but industrial uses for broomcorn stalks are yet in their infancy.

COSTS AND RETURNS

Broomcorn when produced on an extensive scale requires more capital than many other field crops. Some special equipment is necessary, and intensive methods, involving a relatively large cash outlay for labor to perform the handwork, are essential to the successful production of this crop.

The principal items entering into the cost of broomcorn production are man labor, horse and tractor work, seed, threshing and baling, use of equipment, and use of land.

In the standard broomcorn district of east-central Illinois, based on the usual field practice, with a yield of 600 pounds of brush per acre, farmers produce an acre of broomcorn with about 42 hours of man labor, 17½ hours of horse work, and 2½ hours of tractor work. These requirements amount to 140 hours of man labor, 59 hours of horse work, and 8 hours of tractor work per ton and are for farms where tractors are used for plowing and disking. In the Lindsay district of south-central Oklahoma, where the yield is slightly less than in Illinois and where it is not the usual practice to use tractor power, the man labor per acre amounts to about 43 hours and the horse work to about 37 hours for a yield of 500 pounds per acre. On a ton basis it takes about 172 hours of man labor and 151 hours of horse work. These yields are higher than the average for each State, but are representative of average yields obtained on the better soils of the broomcorn area.

In the western or dwarf broomcorn district, represented by southwestern Kansas, where it is not the general custom to shed cure the brush and where less tillage and cultivation are required, these requirements are somewhat less than in the more intensive standard broomcorn sections. For a yield of 333 pounds per acre, about 24 hours of man labor and 17 hours of horse work per acre are required. These requirements amount to 145 hours of man labor and about 104 hours of horse work per ton.

Much of the work comes at harvest time, when extra man labor must be hired. In 1928 harvest wages ranged from 20 to 35 cents per hour with board. Field bosses were paid 35 to 50 cents per hour and occasionally \$1 per acre.

In recent years good seed has cost from \$2 to \$10 per bushel or from 10 to 70 cents per acre for a single planting. The charge for custom threshing ranges in the different areas from \$4 to \$6 per ton and for custom baling from \$1 to \$1.50 per ton where the grower furnishes the crew. In southwestern Kansas seeding and baling combined cost

\$5 to \$6 per ton where the grower furnishes the crew. Growers who own threshers and balers may save some of this expense. Baling wire costs from 60 to 70 cents per ton of brush.

Other costs, including taxes, fire insurance on the brush, use of machinery, use of broomcorn shed, losses due to abandoned acreage, reseeding, and overhead expenses, amount to about \$2 per acre in southwestern Kansas and \$7.50 per acre in south-central Oklahoma and east-central Illinois.

In 1928 broomcorn land was valued at \$150 per acre in east-central Illinois, \$125 in south-central Oklahoma, and \$25 in southwestern Kansas. Interest charges are frequently considered a part of production costs, and when figured at 6 per cent of these, land valuations amount to \$9 per acre in Illinois, \$7.50 in Oklahoma, and \$1.50 in Kansas.

Including interest on land, the total 1928 cost to a group of owner operators was \$15.50 per acre in southwestern Kansas, \$35 in south-central Oklahoma, and \$38 in east-central Illinois. The cost per ton amounted to \$93 in Kansas, \$139 in Oklahoma, and about \$125 in Illinois, on the basis of yields of 333, 500, and 600 pounds per acre in the three sections. Excluding the interest charges, the cost per acre amounted to about \$14, \$27.50, and \$29 in these States, respectively.

Tenant farmers in Illinois usually give as rent a third and in Kansas and Oklahoma a fourth of the crop delivered to market. The 1928 cost of a ton of broomcorn brush to tenant operators was about \$120 in southwestern Kansas and \$128 in south-central Oklahoma and east-central Illinois.

The foregoing costs per ton would be higher with lower yields, higher-priced lands, or if the work were increased by unfavorable weather conditions, and would be less if yields were higher or other conditions more favorable. Costs on individual farms surveyed varied from \$75 to \$200 per ton. Costs in southwestern Kansas are similar to those in Colorado, New Mexico, and northwestern Oklahoma. In much of western Oklahoma costs are between those in southwestern Kansas and in south-central Oklahoma.

Individual lots of broomcorn brush have sold as low as \$40 and as high as \$500 per ton since the pre-war period. The average United States farm price on December 1 during the five years from 1925 to 1929 has varied from \$78 to \$143 per ton. On the farms studied the quality of brush was considerably better than for the country as a whole. In Illinois on these farms the average price received in 1929 was \$175, in Oklahoma \$120, and in Kansas \$115 per ton in comparison with an average United States farm price of \$122 on December 1, 1929.

Broomcorn is seldom more profitable than other adapted farm crops except when broomcorn prices are high. The farm price of broomcorn brush varies widely, according to supply and demand and quality of the brush. In each of these areas there is at least one major competing cash crop, and when, in the opinion of the grower, the price of broomcorn brush becomes unattractive there is a tendency to substitute some other cash crop for at least a part of the broomcorn acreage.

Broomcorn should be grown only in established districts where it can be marketed readily, unless there is a local market, since buyers usually visit only established broomcorn districts. It requires considerable knowledge and skill to produce a good quality of brush, and

unless a grower has had this experience in growing and handling the crop he is likely to produce broomcorn of low quality which will not command a good price.

DISEASES

Broomcorn is attacked by the same diseases that attack other sorghums, and the methods of control are the same.

SMUT

Smut is the principal fungous disease attacking broomcorn. The smut usually found is the one known as covered kernel smut (*Sphacelotheca sorghi*). Different physiologic forms of this disease are known, but they all attack broomcorn. This smut destroys the seeds in the heads and produces elongated galls or masses of dusty, nearly black spores where the seeds should have developed. The brush on badly smutted heads does not develop so well as in sound heads. If the brush is slightly damp when threshed the smut spores will be smeared over the brush during the threshing operation, making it dark and unattractive.

All varieties of broomcorn appear to be susceptible to covered kernel smut. The disease can be controlled, however, by seed treatment. The method of treatment formerly used consisted of soaking the seed in a solution of 1 pint of commercial formaldehyde (formalin) to 30 gallons of water. The seed is placed in sacks and immersed in the solution for an hour and then removed, treated, and spread out to dry. The seed can also be treated by sprinkling with the formaldehyde solution and leaving the pile of seed, which has been stirred while sprinkling, covered with a canvas over night, after which the seed is dried.

Dipping the seed in a solution of copper sulphate (bluestone), 1 pound to 5 gallons of water, also controls kernel smut in broomcorn.

Dust treatments are more convenient to use than the liquid formaldehyde treatment. Copper-carbonate dust, which is used for treating seed wheat to prevent smut, also largely controls the covered kernel smut of broomcorn, but this treatment is not quite so effective as the formaldehyde treatment. Recent experiments have shown that Ceresan, a mercury-compound dust, will completely control the covered kernel smut of broomcorn. This dust should be applied at the rate of about 3 ounces per bushel of seed. The dust can be mixed with the seed in any regular dust-treating machine or by shaking the dust and seed together in a tight box, barrel, or can.

Another kind of smut attacking broomcorn is known as loose kernel smut (*Sphacelotheca cruenta*). It differs from the covered kernel smut in having longer and more slender galls which break up more easily. The loose kernel smut is controlled by the same methods as the covered kernel smut.

The head smut (*Sorosporium reilianum*) of sorghums, for which no satisfactory control method is known, seldom attacks broomcorn.

OTHER DISEASES

Sorghum rust (*Puccinia purpurea*) attacks the leaves of broomcorn but is not known to cause any appreciable losses. No control for this disease is known. The leaf-spot diseases of broomcorn that produce reddish stripes or spots on the leaves apparently are not destructive. They are caused by species of bacteria (*Bacterium andropogoni*, *B. holcicola*, *B. holci*), but no method of control is known.

INSECT PESTS³

Many insect pests common to Indian corn and the grain sorghums also attack broomcorn. Among the more important of these are the corn earworm, common stalk borers, webworms, the army worm, army cutworm, fall army worm, sorghum webworm, green bug, corn-leaf aphid, chinch bug, white grubs, leaf hoppers, and grasshoppers. The control of these pests on broomcorn is, for the most part, similar to the control of such insects on Indian corn and the grain sorghums; however, control measures will differ somewhat because of variation in cultural practices and more particularly the time and method of harvest. Information is usually available on the biology and control of most of these insect pests, and although the damage caused by various species may look the same, the control measures are usually different.

When injury is observed and information desired, specimens of the insects causing the damage, together with a sample of the injured plant, should be sent either to the State experiment station or to the Bureau of Entomology, United States Department of Agriculture, Washington, D. C.

³ Prepared by W. H. Larrimer, Bureau of Entomology, U. S. Department of Agriculture.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

August 15, 1930

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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1632

KARAKUL SHEEP



KARAKUL SHEEP are important chiefly because they produce lambskins suitable for fur. The lambskins are divided into three general classes designated by the trade names broadtail, Persian, and caracul.

The hardiness of this breed, which originated in Bokhara in west-central Asia, would be a valuable characteristic if bred into native flocks in some sections of the Southwestern States where the climate is similar to that of Bokhara.

The purebred Karakul sheep in the United States are not numerous. Only three importations from their native country have been made, one in 1909, one in 1913, and the last in 1914. Further direct importations have been prohibited by law in order to prevent the introduction into the United States of animal diseases prevalent in Asia.

Karakul sheep now on hand can be used for grading up by mating selected purebred Karakul rams with ewes of the more available American types. Experimental work has indicated that high-grade Karakul sheep which will be as satisfactory as purebred Karakuls in the production of commercial fur can be developed by mating successive generations of select-grade ewes with purebred Karakul rams especially prepotent in transmitting desirable fur characteristics.

KARAKUL SHEEP

By C. G. POTTS, *Animal Husbandman, Animal Husbandry Division, Bureau of Animal Industry*

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BREED CHARACTERISTICS

THE KARAKUL BREED of sheep is of the fat-tail type, the tail being broad, flat, and tapering rapidly toward the end. The fat stored in the tail enables the sheep to withstand long periods on scant feed. The head is peculiarly characteristic of the breed, the face being black and narrow, the skull much rounded, with Roman nose and thin, black, pendulous ears. The legs as well as the face and ears are covered with short, fine, lustrous, black hair. The ewes are generally hornless but the rams usually have long, spiral, outspreading horns. (Fig. 1.)

The wool is coarse and long and varies in color from black through various shades of brown to light gray. Practically all lambs are black at birth and continue that color until they are yearlings, after which the wool gradually becomes a lighter shade. However, this change of color is not uniform in all animals, some remaining rather dark in maturity, whereas others become very light. The title-page illustration shows a purebred Karakul ewe and lamb. Note the tight curl of the lamb's coat, which has a high luster. This is the type of skin desired for fur.

The breed is noted for its hardiness and is able to exist and do well under very adverse conditions. In their native home, Bokhara, in west-central Asia, the sheep are kept in the mountains through the summer and are driven to the lowlands for wintering when the mountains are covered with snow. Although the Karakul is found in its greatest purity in Bokhara, especially in the Karakul Valley, animals with a large percentage of Karakul blood are found in various other countries as far west as the Caspian Sea, and also in that section of southern Russia adjacent to the Black and Caspian Seas.

IMPORTATIONS OF KARAKUL SHEEP

Three importations of Karakul sheep from Bokhara totaling 34 rams and 33 ewes, were brought into the United States in 1909, 1913,

and 1914. The offspring of these sheep are now widely scattered throughout the United States and Canada, the greatest numbers of both grades and purebreds in the United States being in Texas, New York, Michigan, Colorado, and South Dakota.

CLASSES OF LAMBSKINS

This breed is particularly prized for the production of lambskins, utilized as fur, which may be roughly divided into three classes, commercially known as broadtail, Persian, and caracul. Of these three classes the broadtail is the most valuable, but the percentage of this type of skin produced is very small. It is produced usually by lambs prematurely born, although cases are reported of this type of



FIGURE 1.—Good type of Karakul ram. The coarse, wavy, lustrous fleece is typical of the best individuals of the breed

fur being produced by lambs born at full fetal development. It is a flat, lightweight fur with a water-wave pattern which is very lustrous and beautiful. The fact that practically all lambs from which this most valuable type of lamb fur is taken would be a total loss (since they are stillborn) in the production of other breeds is one of the important advantages in producing the Karakul breed. Broadtail skins are used almost entirely for making ladies' coats. (Fig. 2.)

"Persian lamb" is a type of skin produced by lambs of the Karakul breed which are from 3 to 10 days old. It is necessary to watch the skins carefully, because the curl opens rapidly after the fifth day, and while the value increases with the size as long as the curl remains tight, it is essential that the pelt be removed before the quality of the fur is reduced. In some cases this is as late as the tenth day after birth. As far as is known, no artificial means has

been developed of increasing the curl or in any way changing the pattern after birth. This type of fur (fig. 3) is used in making ladies' coats and in trimming coats of other materials for both men and women.

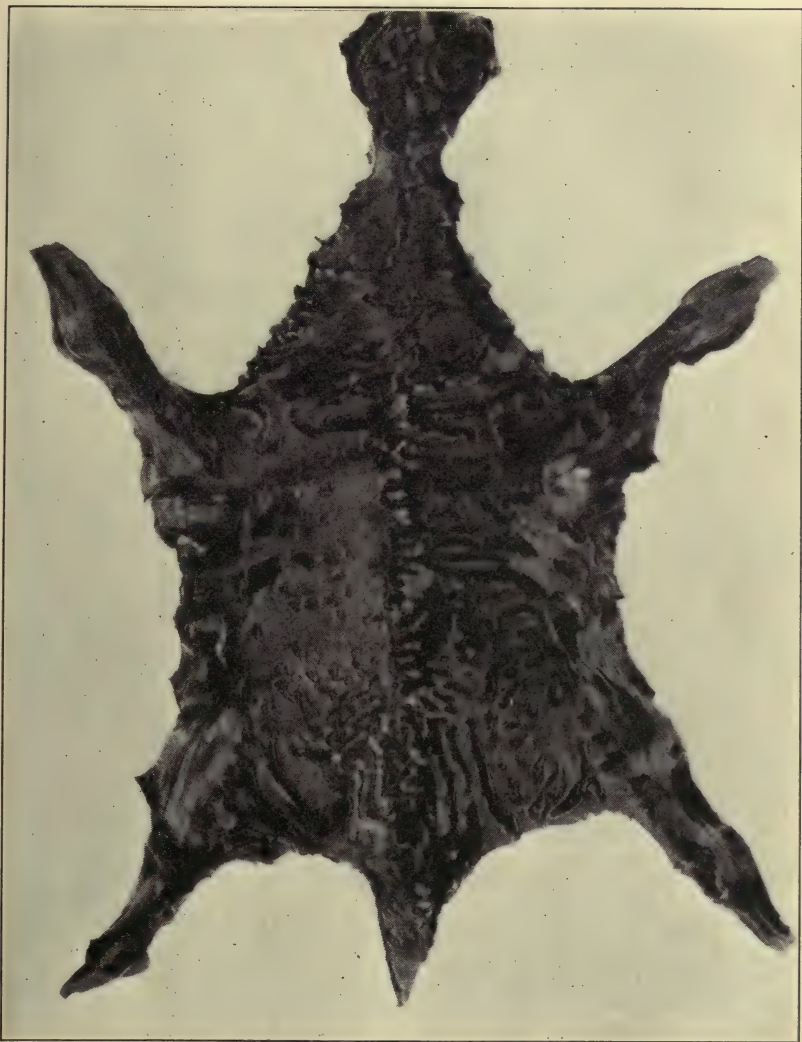


FIGURE 2.—Skins classed as "broadtail." These skins should be extremely lustrous and of light weight

"Caracul" is a trade name given to a lustrous, open type of fur (fig. 4), which shows a wavy or moiré pattern and is entirely free from close curls. These skins are usually light in weight and are very desirable as materials for ladies' coats. They occur naturally in black as well as in various shades of brown and tan. The tendency to lighter shades is an individual characteristic of the type of sheep producing this kind of fur. The skins are best when removed at an

age not greater than two weeks, but they do not deteriorate with age so rapidly as either the broadtail or the Persian type. They can be used for fur as long as the luster is retained, which may be as long as two months. The term "caracul" means this type of fur and not the Karakul breed of sheep, in spite of the similarity of the names and the fact that caracul fur is produced by lambs of the Karakul breed.



FIGURE 3.—Persian lambskin. This type of fur is more open, with looser curls, than broadtail. Its value is determined largely by uniformity of pattern and lustrous appearance

Various methods have been used in curing the raw skins for shipment. Some are dried in the shade, some pickled, and others are treated with a mixture of barley meal and salt while the fur is sprinkled with flour or sand to keep the curl from opening up. They should never be doubled or salted, as this may cause the skin to break. In packing, the fur sides of the skins should always be placed together to avoid injury by the contact of the raw skin with the fur.

KARAKUL WOOL

The wool which is sheared from Karakul sheep is lustrous but coarse and varies in color from a light gray through various shades of brown to black. It ranges in length from 8 to 12 inches, and the fleece weights usually range from 7 to 9 pounds. This wool can be made into beautiful rugs and carpets and is also used in the manufacture of blankets and automobile robes. However, its uses are

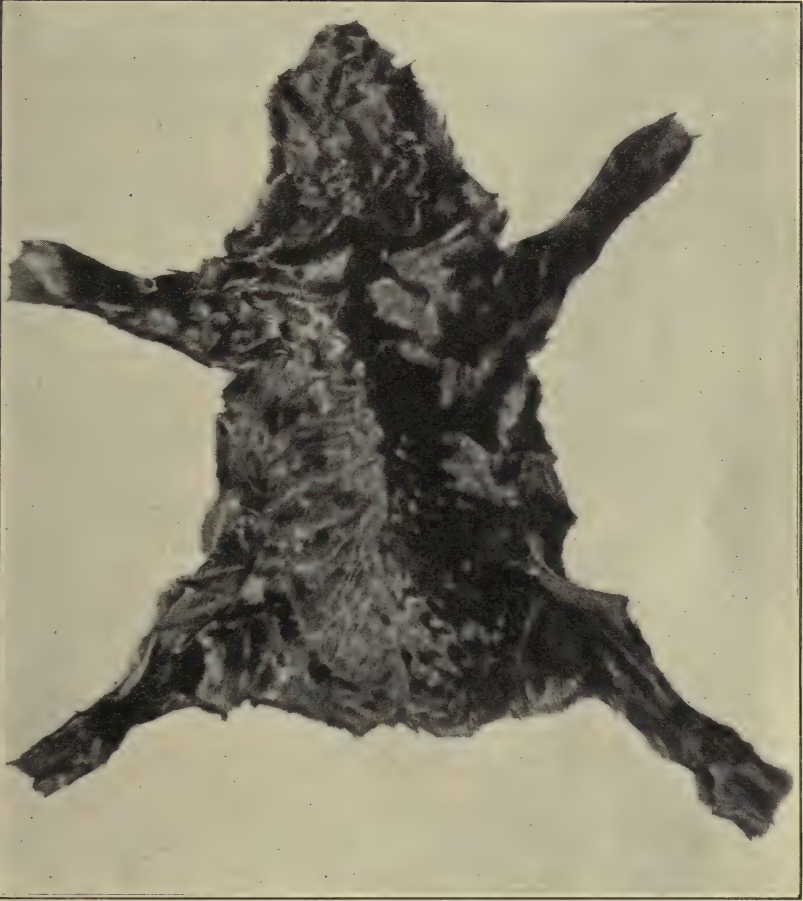


FIGURE 4.—Skin classed as "caracul." The value of this type of fur depends on the character of the wave and the luster it shows. The most valuable skins are light weight, with a pronounced, satiny sheen

rather limited when compared with those of the finer grades, and when handled through regular marketing channels Karakul wool sells at from one-half to three-fourths the price received for good-quality white wool produced by the breeds of sheep that are more thoroughly established in the United States.

CHARACTERISTICS OF THE MEAT

While Karakul lambs are hardy and grow out well, they are rather angular in conformation and are not so well developed in those por-

tions of the carcass that yield the most expensive cuts of meat as are the more specialized mutton breeds. The hardiness of the lambs is due, no doubt, to the ability of the breed to withstand the long periods of short feed and the semiarid conditions which prevail so extensively in the country in which they are commonly raised.

Since the Karakul is primarily a fur-producing breed, no attempt has ever been made to develop a mutton strain. Nevertheless, the meat is wholesome, and the wether lambs can be marketed to defray part of the expense of production while grading up the ewe flock to a point where the pelts of the lambs will be more valuable as fur than the lambs would be for meat if grown to marketable size.

UTILIZATION OF THE BREEDING STOCK

Only a small number of Karakul sheep have been imported into the United States, and further direct importations from the countries of which the breed is native have been prohibited by legal restrictions on account of certain serious diseases of animals in those countries. Multiplication of the Karakul sheep already on hand in this country must be through breeding, and their qualities may be extended further by grading up other breeds to the Karakul type by the use of purebred Karakul rams. Purebred Karakul ewes, of course, should be mated with purebred Karakul rams. This purity of breeding can be maintained, and at the same time a ram bred to a limited extent to purebred Karakul ewes may also be mated with a rather large number of ewes of other more available American types.

Five successive crosses of the female offspring to purebred Karakul rams result in sheep that are thirty-one thirty-seconds, or approximately 97 per cent, pure Karakul breeding. But it is not expected that ewes of even this high grade will be as valuable for the production of fur as is the best imported stock. However, since some of the imported animals have not proved to be satisfactory for the production of valuable fur, it is doubtful whether imported Karakul sheep, on which little or no definite information can be obtained before shipment, would be better than selected grade animals of a high percentage of choice, pure breeding, or even as valuable.

Karakul sheep have been crossed, to a limited extent, with Rambouillet, Merino, Lincoln, Cotswold, and other breeds in the United States, and good, marketable skins have been produced by this grading-up process. Though information on the results is limited, the true Karakul type is evidently prepotent in the best individuals of known parentage, which trace in pure blood lines through the sire and dam to some of the best imported animals.

The hardiness of Karakul sheep is a valuable characteristic which may be introduced, through breeding, into some of the common American breeds. Karakul inheritance in flocks of grade sheep in some dry or semiarid regions of the United States where the climate is similar to that of Bokhara doubtless would enable the grade sheep to withstand adverse weather conditions better than the native flocks.

CROSSBREEDING AND GRADING UP

From 1911 to 1914 the Bureau of Animal Industry conducted crossbreeding experiments with Karakuls, using Cotswold, Cheviot, and Merino ewes, as well as a number of woolless ewes of the Barbados breed. Although Blackfaced Highland and Lincoln ewes are understood to be very satisfactory for this purpose, lack of space and satisfactory breeding stock prevented their use in these experiments.

Of eight skins taken from lambs produced by Cotswold ewes to the service of Karakul rams, three were valued at \$1 each in the raw state, although all were black and showed considerable curl, as do the skins of practically all first-cross lambs sired by Karakul rams. A skin may be black and curly and yet have little value because it lacks luster and has a poor style of curl.

Six skins were procured from lambs produced by Cheviot ewes bred to Karakul rams. One skin was valued at \$3 and one at \$1. The others did not have sufficient value as fur to pay the charge of 50 cents each for "dressing," the trade term for preparing the skins for use as fur. The dressed skins were appraised by New York furriers.

Of five skins from lambs of Merino ewes sired by Karakul rams, none had sufficient fur value to repay the charge of dressing. These skins were particularly poor in luster and the character of curl was still poorer than in the other crosses mentioned above. (Fig. 5.)

The better of the two rams used in the above-mentioned crosses was mated with Barbados ewes from which 59 lambs were produced. Barbados sheep have short, rather stiff, hairy coats, and it was thought that these ewes might be suitable for use with the Karakul rams. From these 59 first-cross lambs 33 ewes were kept for experimental breeding. None of the skins produced by the remainder had any fur value, although the quality was much the same as that of the skins of the 33 ewes kept. (Fig. 6.)

It was thought that, even though the first-cross Karakul-Barbados did not yield skins valuable for fur, they might be valuable as breeding stock in grading up to Karakul blood by the successive use of Karakul rams.

In the spring of 1913, 15 of these first-cross ewe lambs were bred to a second, imported Karakul ram. These ewes produced 18 lambs the following August, of which 7 rams and 1 ewe were killed. Their skins ranged in value from \$1 to \$10 (based on October, 1913, prices), averaging \$4.70 each. Sixteen Karakul-Barbados ewes, the same lot as those bred in the spring, were bred in the fall of 1913 to a third Karakul ram and produced 25 lambs in the following spring. There is apparently much difference in the prepotency in individual Karakul rams, as the second lot of lambs was much inferior to the first lot from the same ewes. Nine rams and one ewe of this lot were killed and of the 10 skins produced the best two were valued at \$3 and \$1 each. The others had very little or no value as fur. These prices also were fixed by New York furriers.

While seasonal climatic conditions and feed may have had some effect on the quality of the skins produced by this lot of ewes in the two successive lambings, much of the variation was believed to

be traceable to the greater prepotency of the sire of the first lot in transmitting the fur characteristics to his offspring. These ewes were to have been bred again in the spring of 1915 but were destroyed in a fire. Their loss ended the experiment.

GRADE KARAKUL RAMS AS SIRES

The scarcity of purebred Karakul rams and the high value placed on them has led to the use of grade rams in many cases. Since a



FIGURE 5.—Skin from first-cross Karakul-Merino lamb—black, but poor in character of curl and luster. This skin has no fur value

half-blood ram has a dark fleece and shows some waviness of his fleece even when mature, he will often appear to be valuable as a sire, especially to those inexperienced in this type of sheep production. Although, as stated, such rams, when bred to longwool ewes, may sire lambs which are black and curly, the skins of these lambs are not necessarily valuable as fur.

In April, 1914, four lambs sired by crossbred Karakul-Barbados rams were produced by ewes of the same breeding as the rams. These lambs were of the same general appearance as the first-cross Karakul-Barbados lambs which had no value for fur purposes. In the same spring seven Karakul-Barbados first-cross ewes were bred to a three-quarter-Karakul-one-quarter-Barbados ram which had at birth a skin valued at \$10. As a result of these matings 10 lambs were produced which theoretically were five-eighths Karakul blood, but none of these lambs had skins of fur value.

The results of these experiments provided further evidence that little could reasonably be expected in the production of valuable fur from the interbreeding of grade Karakul rams and ewes. However, some benefit from the use of these grade rams may be derived through the infusion of Karakul blood into flocks of other breeds, for foundation stock to be graded up later for fur production by the use of purebred Karakul rams. While there is little or no possibility of pro-



FIGURE 6.—Crossbred Karakul-Barbados ewe lambs, showing loose curls and lack of luster, which are typical of the first-cross lambs and are undesirable for fur

ducing marketable furs from the mating of grade Karakul rams with grade Karakul ewes, the use of selected purebred Karakul rams for this purpose shows much promise of success. The results of these tests and the personal knowledge which the writer has of results obtained by breeders, in grading up flocks carrying a preponderance of Karakul blood, indicate that a type of sheep can be developed which will be entirely satisfactory for the production of marketable skins. Success in developing such a type of sheep will depend on the continued use of the best purebred Karakul rams now available in this country on successive generations of choice, grade Karakul ewes.

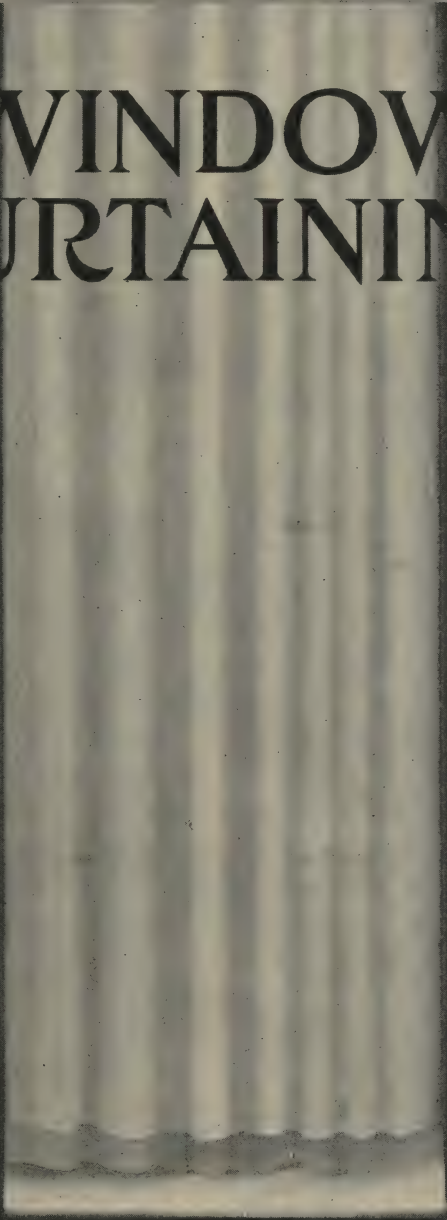
The various organizations in the United States which have been maintaining separate registers for Karakul sheep have now combined to form a national organization under the name "Karakul Fur Sheep Registry," in which all animals tracing in all ancestry to imported stock may be recorded. A. G. Granger, Kadoka, S. Dak., is secretary of this registry association.

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FARMER'S BULLETIN No. 1633

WINDOW CURTAINING



TYPICAL CURTAIN FABRICS

CURTAIN FABRICS for every type of house and window can be found in 100 or more standard and novelty materials on the market. This brief list merely suggests the range of cottons, silks, wools, and rayons suitable for glass curtains and draperies:

FOR GLASS CURTAINS

Batiste.	Marquissette.	Pongee.
Cheesecloth.	Mull.	Scrim.
Dimity.	Nets and laces.	Swiss.
Lawn.	Organdie.	Theatrical gauze.
Madras.	Pineapple cloth.	Voile.

FOR SIDE DRAPERIES AND DRAW CURTAINS

Armure.	Damask.	Prints.
Brocade.	Drapery denim.	Rep.
Burlap.	Gingham.	Satin.
Casement cloth.	Japanese crêpe.	Showerproof fabrics (for bathroom and kitchen).
Challie.	Madras.	Taffeta.
Chintz.	Mohair.	Terry cloth.
Corduroy.	Monk's cloth.	Velour.
Cotton homespun.	Osnaburg.	Velvet.
Crash.	Percale.	Velveteen.
Cretonne.	Poplin.	

This bulletin is a revision of and supersedes Farmers' Bulletin 1516, Principles of Window Curtaining.

Washington, D. C.

September, 1930

WINDOW CURTAINING¹

By BESS M. VIEMONT, *Assistant Specialist in Textiles and Clothing, Textiles and Clothing Division, Bureau of Home Economics*

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CURTAINS are one of the leading items in the outlay for household textiles. To curtain the windows of even a 5-room house about 60 yards of material are needed, and every few years curtains must be replaced. Since the attractiveness of a house depends in large measure on the success of the curtains, this bulletin has been planned as a guide for the home maker in selecting, making, and hanging curtains suitable for the average home.

The type of window treatment to choose depends upon the part it is to play in the decorative scheme as a whole and upon the purposes it must serve. Curtains may be used to exclude an unpleasant view, to soften and diffuse the light coming through the window, or to frame an attractive outlook. Through careful choice of colors and textures, draperies may also serve as a connecting link between the walls and other furnishings.

Making curtains and draperies is not difficult. It is more economical in the long run to select durable material that will withstand sunlight and tubbing and make curtains at home than to expend the same amount of money for ready-made curtains of poorer quality. Careful measurements and accurate cutting are most important for good results. Detailed directions for making different kinds of curtains are given on pages 19 to 29.

ART PRINCIPLES APPLIED TO WINDOW CURTAINING

Planning curtains is not a matter of inspiration alone. There are definite laws to aid in deciding what kind of curtains should be used in various rooms and with different types of furnishings. An understanding of these design principles simplifies planning of draperies and makes it possible to tell ahead of time what will be the effect of certain arrangements (Fig. 1).

¹ This bulletin is a revision of Farmers' Bulletin 1516, Principles of Window Curtaining, by Mary Aleen Davis, formerly Junior Specialist in Textiles and Clothing, and acknowledgment is hereby made for the portions of text and the illustrations that appeared in the earlier publication.

Window curtains, together with walls, floor, and ceiling, form the background for the furniture and occupants of a room. Curtains may give accent to the room through appropriate choice of color and line, but in most cases they should be subordinate in interest. Any room generally needs two or more centers of interest, but they must be so planned as to balance each other. If the curtains vie with the rugs, the rugs with the davenport, and the davenport with the pictures for dominance, there is lack of repose. The lines, mass, color, and texture of the draperies must be so carefully planned that they blend quietly into the rest of the room.

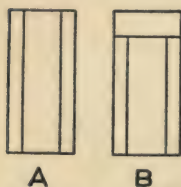


FIGURE 1.—The lengthening effect of vertical lines and the broadening effect of horizontal lines in curtaining windows. B appears shorter and wider than A because of the horizontal line at the top.

PROPORTION

Proportion is the relationship of all parts of an object to the whole and to each other. In planning window curtains, problems in proportion arise when the width of valances, the width and position of side draperies and trimming bands, and the size of pattern in the fabric are being considered. According to the Greek law of proportion, the ratio between units should be approximately 3 to 5, 5 to 8, 8 to 13, and so on. In other words, equal spaces are uninteresting and mechanical and are to be avoided. Interest is created only when the spaces or masses are so well proportioned that they are not immediately evident, and the eye is led to calculate the relation of one to the other.

The lower edge of curtains and draperies should be in a line with some structural part of the wall. Glass curtains usually reach to the sill, but side draperies should come to the sill, to the bottom of the apron, to the top of the baseboard, or should barely escape the floor.

Oftentimes the unsightly effect of a poorly proportioned window may be overcome through choice of materials and arrangement of side draperies and valances. Thus, if a window is too broad and low, the side draperies may be of a fabric with vertical stripes, and spread over part of the window to reduce the expanse of glass. The valance can be placed above the casing so as just to reach the glass; or it may be reduced to a mere ruffle, or omitted entirely.

To make a tall, narrow window appear average in height and width the rods may be mounted on the wall instead of on the casing so that the draperies come just to the glass. (Fig. 2.) Sill-length draperies lessen the apparent height still more. To give the same effect, material with a large sprawling design or horizontal stripes may be chosen.

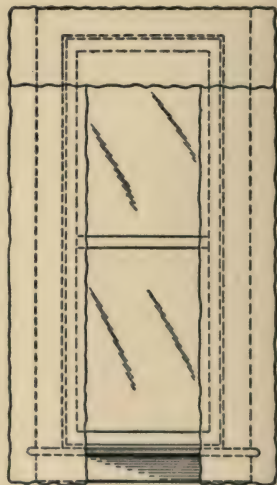


FIGURE 2.—Proportions of a tall window modified by placing the curtain rod out on the wall

LINE

Line has been defined as the direction in which the eye is carried by prominent structural or decorative parts of an object. Thus the lines

of a curtain are determined by the way the curtain is made and hung, by the design in the fabric, and by the trimming. A good window treatment has lines that suggest the spirit of the room and that conform to its general proportions. If these proportions are poor, then well-planned curtains may help to conceal some of the defects.

Vertical lines are formal and dignified and give an effect of height. They are particularly desirable in public halls and reception rooms and when wisely used are suitable in the more formal rooms of a private house.

Horizontal lines are formed by valances, tie-backs, trimming bands, and double-sash curtains. They tend to decrease the height of a room and give an informal effect. When used in the form of a valance, cornice, or pole with vertical side draperies, the most pleasing window treatments are obtained, because the eye, instead of stopping at the top of the side draperies, is carried across the top and around to the sill without a break.

Apparent height may be increased by the use of vertical lines, or it may be reduced by horizontal lines, as shown in Figure 1. The outside measurements of A and B are the same, the spacing of the vertical lines is identical, yet B appears much wider and not so tall as A, because of the horizontal line at the top.

Curved lines are graceful and may be interesting, but they have a tendency to make a window appear large. Good and poor uses of curved lines are illustrated in Figure 3. The draperies in A and B are evenly balanced. They have strength

and dignity combined with charm and variety of line. Such uneven balance as Figure 3, C, is faddish for window decoration and should be used sparingly. An example of the way in which the symmetry of the window frame is sacrificed to superfluous lines and heavy fabrics is shown in D.

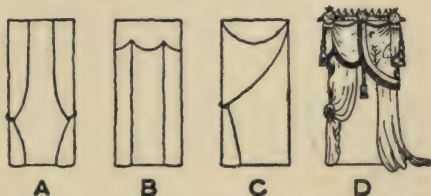


FIGURE 3.—Effect of curved lines in window treatments: A and B conform to the general outline of the window; C, curves that weaken structural lines; D, an overelaborate arrangement of curves

COLOR

Color has an impelling force and is perhaps the most important single factor in window decoration. Artistic color selections can correct bad proportions, strengthen weak lines, or modify the quality of light entering the room.

COLOR QUALITIES

There are five principal hues or colors—red, yellow, green, blue, and purple. A countless number of intermediate hues may be obtained by mixing two or more of these basic colors together in varying proportions. The brightness of these hues is designated in terms of light and dark. By mixing with white the higher values, or tints, are obtained; and by blending with black, lower values, or shades, are produced. Of the two, shades are more subtle and are generally preferable for use in living rooms. Tints are more appropriate in bedrooms. There, draperies light both in color and in weight, are attractive when the woodwork and furniture are tinted; but in a room with dark oak panels and ponderous dark furniture, such draperies

seem weak and trivial. Large pieces of furniture and dark woodwork require colors low in value and intensity, and a curtain heavy enough in weight to balance them. Dark rich colors and heavy fabrics give an effect of luxury and are appropriate in formal rooms but are not suitable in an informal decorative plan. Small amounts of intense colors are sometimes needed to give accent to an otherwise monotonous combination. They may be introduced in bindings and facings on side draperies or in tie-backs. Solid intense colors for window draperies should be confined to the sun room or possibly the breakfast alcove. Even in these rooms a figured material with a neutral background and a predominance of grayed hues relieved by some intense color would be more pleasing.

Red, yellow, and hues related to them are classed as the advancing colors. Red is the most stimulating and yellow the most luminous. Since these are colors associated with sun and fire, draperies of them counteract the gloom in a dark, cheerless room. They must be used judiciously if the room is small, or their effect will be overpowering. For glass curtains, soft orange, pale yellow, pinkish cream, rose, or mulberry will give a warm cast to the light coming through the window; but as a general thing, cream color, *écru*, or a warm tan is a more satisfactory choice. Pure white curtains are only appropriate with white woodwork and very light-colored wall paper.

Blues, greens, and violets suggest distance and coolness and are called the receding colors. In climates where the sunlight is intense most of the year, these colors are restful in any room regardless of exposure. Greens and blues, however, must be used cautiously in glass curtains, because the transmitted light may be unpleasant. In moderate climates, warm colors, rightly used, are successful for any season.

COLOR PLANS

In choosing the color for curtains, as in applying the various other principles of art, the room as a whole should be studied. When draperies are figured a more harmonious effect is gained by selecting a fabric in which the background is the same color or slightly darker than the walls and in which the principal color in the design repeats the color of the rug or the upholstery. Decided contrasts in color and value are permissible if repeated in some other furnishing of the room.

A distinctive color plan for a sunny room may be worked out in shades, tints, and grayed tones of one color. Interest is then created through contrasts in texture. The walls and woodwork may be a very light value of soft, grayed blue-green and the rugs a lower value of the same color. Against this background almost any color could be used in the curtains and furnishings. A creamy tan cretonne with yellow, blue-green, and red-purple predominant in the design would be interesting. If this were used for side draperies, glass curtains of square-meshed net or a similar plain, thin fabric would be necessary. However, if the cretonne were used for upholstering or for slip covers, glass curtains of maize-colored theatrical gauze, cream-colored scrim, or marquissette would make a pleasing contrast. The design in the cretonne should govern the type of curtain. For example, if the cretonne were striped, the glass curtains should hang straight, and blue-green crossbars should be used in the scrim or marquissette. But if the cretonne design suggested curves, soft material with blue-

green dots would be a good choice for the glass curtains, and they might be finished with ruffles of the same material and held with tie-backs of blue-green.

For the room that receives a cool north light, cream-colored walls, printed linen or cretonne draperies with orange on a soft, warm, brown background, combined with sheer orange-colored glass curtains would furnish the necessary brightness.

A more subtle color scheme and one handled with little difficulty, combines two or more colors having one hue in common. Pure green, blue-green, and yellow-green in varying proportions, values, and degrees of brilliance would compose a harmony with the two components of the colors, blue and yellow. Interest is added by a note of a color in contrast, such as a pillow, a bowl, or book bindings of red-violet.

Another type of harmony is produced by combining complementary colors or those opposite each other in the color wheel. Such combinations as yellow and blue-purple, blue and orange, red and blue-green, red-purple and green, yellow-green and purple are the strongest contrasts possible, and the colors should never be used in equal quantities or in equal values. But when a green is decidedly gray and very light in value it makes a delightful background for deeper green and mulberry striped draperies.

No color system has been generally accepted by which the hue, value, or intensity of a particular color can be indicated, and definite impressions are difficult to carry in the mind. For these reasons draperies should not be purchased without first seeing a large sample of the material in the room against the walls and furnishings, in order to study the effect of natural and artificial light on the combinations as well as the effect of light shining through the fabric.



FIGURE 4.—Boldly patterned side draperies hung from a wrought-iron rod placed well above the window opening give height and dignity to a short wide window

The color scheme of the draperies should be planned with the whole house in mind so that the dominant colors in adjacent rooms harmonize. Many persons find it disturbing to go from a rose-and-blue living room through a green hall into an orange dining room, or to look up from the street at an otherwise attractive house and see different colored curtains in nearly every window. A checkered appearance on the outside can be prevented by using uniform glass curtains and cream-colored linings in all the draperies. Or if colored glass curtains are chosen, they should be alike at all windows on the same wall elevation.

FABRIC TEXTURE AND PATTERN

Not only do color, line, and proportion play an important part in window curtaining, but texture and pattern of the fabric need as



FIGURE 5.—Novelty casement cloth draw curtains of cotton, finished with a French heading. They supply an excellent background for the colorful rugs and pictures, and diffuse but do not cut out the light

careful thought. By texture is meant the effect of weave and fiber on the appearance of the fabric. Textures are thick and thin, smooth and rough, stiff and soft, lustrous and dull, clinging and fluffy.

The spirit and the character of the room determine to a large extent the texture that should be used. Lustrous satin draperies are out of keeping in a rough plastered room with a huge stone fireplace, beamed ceiling, and small casement windows, whereas a rough-textured fabric, such as burlap, osnaburg, or cretonne, harmonizes. Organdie, swiss, or voile curtains are suitable with dainty, painted furniture. Tapestries, velours, or other heavy fabrics are needed to balance massive pieces. With less elaborate furnishings, a cotton novelty such as is shown in Figure 5, or printed linen, rayon, or lightweight silk is appropriate.

Textures to be used together at the same window must also be chosen carefully. With cretonne draperies, glass curtains of scrim, marquissette, or linen gauze are pleasing, but silks call for fine net, lace, or silk gauze. Denim, monk's cloth, and crash may be combined with theatrical gauze, fish net, and other coarse-meshed materials.

The textures used for draperies tend to modify the proportions of the window. Heavy, coarse materials and lustrous, deep-piled fabrics such as velvet, velour, and corduroy, seemingly increase the size of the window and decrease the size of the room. Filmy, light-colored glass curtains used alone at windows have the opposite effect.

The design of the fabric likewise should be in scale with the room and window. Small patterns belong in small rooms at small windows, and large patterns in large rooms at large windows. If reversed, large patterns seem to fill a small room and make small windows seem smaller. Also small designs at large windows may seem trivial and the beauty of a small pattern may be lost in a large room. Like color, richness of design catches the interest and seems to increase the bulk of any object. The large formal designs

of many damasks belong in spacious, formal rooms, but small-patterned chintzes or cretonnes produce a friendly atmosphere.

Curtains may be tied to the rest of the furnishings by making slip covers or by upholstering one or two chairs in the same material if it is suitable. However, too frequent repetition of much pattern is distracting. Figured wall paper calls for plain curtains, and the monotony of plain walls may be relieved by a fabric of appropriate pattern. (Figs. 6 and 7.)



FIGURE 6.—Figured draperies form interesting contrasts with plain walls

KINDS AND USES OF WINDOW CURTAINS

The recognized curtains for windows are generally classified as glass curtains, side draperies, valances, draw curtains, and shades. All may be used at one window, or they may be combined in various ways. Thus side draperies, glass curtains, and a shade may be sufficient for a living-room window. Ruffled glass curtains with a valance of the same material and a shade are perhaps more appropriate for a

bedroom window, and casements are attractive when curtained with draw curtains alone.

GLASS CURTAINS

Glass curtains are made of thin, translucent fabrics. They may cover all or part of the glass of the windows. Such curtains generally come only to the sill, but the appearance of a short, wide window may be improved by extending them to the lower edge of the apron. (Fig. 8.)

As a rule, glass curtains are desirable at all windows, although small-paned casements and those that open out on a beautiful landscape may be the exception. Glass curtains diffuse and modify the color

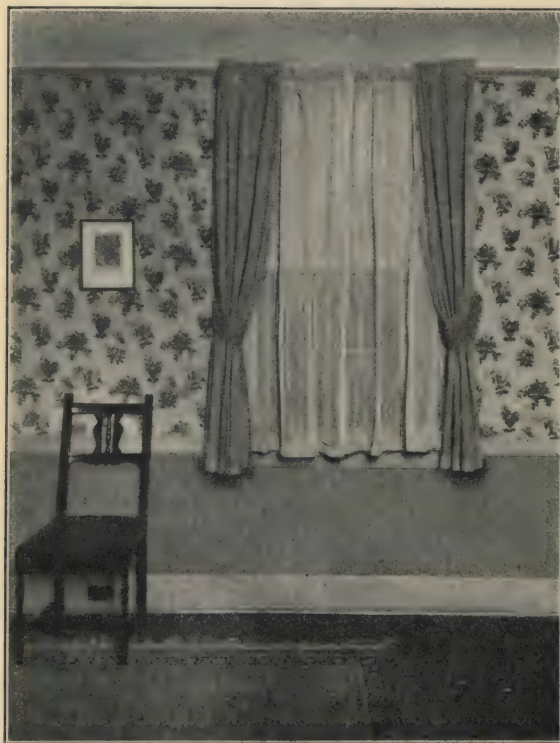


FIGURE 7.—Curtains of plain material should be used with figured wall paper

of light as it shines through, protect side draperies, lend a feeling of privacy, and give a unified effect to the exterior of a house when the same type is used at all the windows.

Materials commonly used for glass curtains are net, marquisette, scrim, voile, theatrical and silk gauze, and lace. Net transmits the most light, but when laundered should be dried on stretchers to prevent excessive shrinkage. All of these thin materials are likely to shrink some in either washing or dry cleaning. Cloth woven evenly from tightly twisted yarns will shrink less and give better service than fabric made from soft, loose yarns. Since every imperfection in weave is brought out by the direct light shining through the curtain, the material should be carefully examined for knots and weaknesses before it is purchased.

SIDE DRAPERIES

Side draperies are usually of heavier material than glass curtains. They subdue the light in a room, are a substitute for shades if arranged to draw, give a finished appearance to the window, and serve to unify the color scheme.

In rooms where the window proportions are good, the length of side draperies should be determined by the style of the season, the fabric, and the effect desired. Some years decorators advocate floor length for all side draperies, and other seasons the shorter length is more popular.

Fine, firm, pliable material hangs and looks best for draperies, and there is a wide range of fabrics from which to choose. At present some of the most popular are cretonnes in plain, twill, and novelty weaves, printed linens, and glazed chintzes, which have the added advantage of shedding dust.

When purchasing drapery materials, in addition to their decorative value, consider the kind and quality of the fiber and yarn, how the fabric is woven, the number of threads to the inch, the finish, and the fastness of the dye. The initial expense of good material may be justified by longer wear and permanent beauty. Cheap, clay-filled cretonnes that become stringy and faded after the first washing, or shiny gauzes that lose their luster, are expensive selections.

Reliable information on the action of light and air on curtain fabrics is meager. Weighted silk has been known to rot at a window in less than a year. Pure silk seems more resistant, but for curtains it does not compare in durability with cotton and linen.

VALANCES

The valance is the part of the drapery that is placed across the top of the window. Good decoration demands that side draperies accompany the valance, and that it never be used alone. Full valances may be gathered, plaited, or shirred; others may be fitted or draped. In any case they should unify the color scheme, give a finish to the window treatment by carrying the eye across the top, and counteract the stiff uncomfortable effect given by the parallel vertical lines of side draperies alone.

Plain gathered valances are the easiest to make, and are the best kind to use if curtains must be laundered frequently. Fitted valances suggest stability and dignity and are suited to formal rooms. Midway between are those with box plaits and French headings. Valances may be trimmed with fringe, bands of contrasting material, ruffles, galloons, cords, and tassels, or they may have stenciled, appliquéd, or embroidered designs.

Valances have a lowering effect on room and window height. This can be partly overcome by modifying the width and the position from which they are hung. Ordinarily, valances are hung from the top of the casing and are approximately one-sixth of the length of the side draperies, or an average of 8, 12, or 15 inches. Greater height can be given in extreme cases by placing the valance up on the wall or so that it just covers the casing, or by hanging it in its normal position and reducing the width to a mere ruffle (figs. 6 and 17), or by introducing different shaped arrangements. A wrought-iron rod (fig. 4),

a painted pole (fig. 8), or a cornice board decorated to harmonize with the draperies, is often substituted for the narrow valance.

DRAW CURTAINS

Draw curtains, or traverse curtains as they are sometimes called, were primarily intended as a substitute for window shades, but they have come to have a wider use. In some decorative plans they are used alone at windows (figs. 5, 10, and 13); in others, they are combined with glass curtains and when pulled back form side draperies. Sometimes in rather elaborate window treatments they are an extra set

of curtains hung between side draperies and glass curtains and are drawn together only at night. Occasionally glass curtains are arranged to draw, as in Figure 4; but for draw curtains heavier fabrics such as cretonne, casement cloth, mohair, linen, silk, and rayon are preferable. Draw curtains may reach the lower line of the apron or the floor, but in deep-set windows they should extend only to the sill.

SHADES

Shades serve to exclude glare in daytime, maintain privacy at night, and give decorative value to windows. They should be chosen for their opaqueness, durability, and color.



FIGURE 8.—Gaily colored chintzes are always appropriate in the colonial bedroom. The painted wooden pole and rings add interest and assist in carrying out the color scheme

Their durability depends upon resistance to cracking and breaking, the success with which they may be cleaned, and the effect of sunlight on fabric and color.

A commercial shade may be used; or linen, glazed chintz, Austrian cloth, or oilcloth may be substituted on the roller for the usual material. (Fig. 9.) The three general types of commercial shades are Holland, painted cloth, and pyroxylin impregnated. All of these are made with a foundation of cotton fabric, either muslin or cambric. Holland cloth is prepared by filling the dyed cotton fabric with a heavy sizing mixture and then passing it between friction rolls to give

it a smooth, glossy appearance. Such shades are available in different grades that vary in quality of both foundation cloth and finish. Painted shades are made by applying a mixture of sizing and either water-color or oil paint to the fabric base. In some of the better qualities the sizing mixture is applied first and an oil paint put on as a top coat. In a "tint" cloth, cambric is the usual foundation, and just enough paint is applied to tint the material. This type is often called the translucent cambric shade. A pyroxylin shade has a muslin base that has been impregnated with a substance known as pyroxylin, which hardens when dry and makes the fabric waterproof.

As there are so many qualities available, it is well to purchase shades from a merchant who can give samples for testing. By rub-

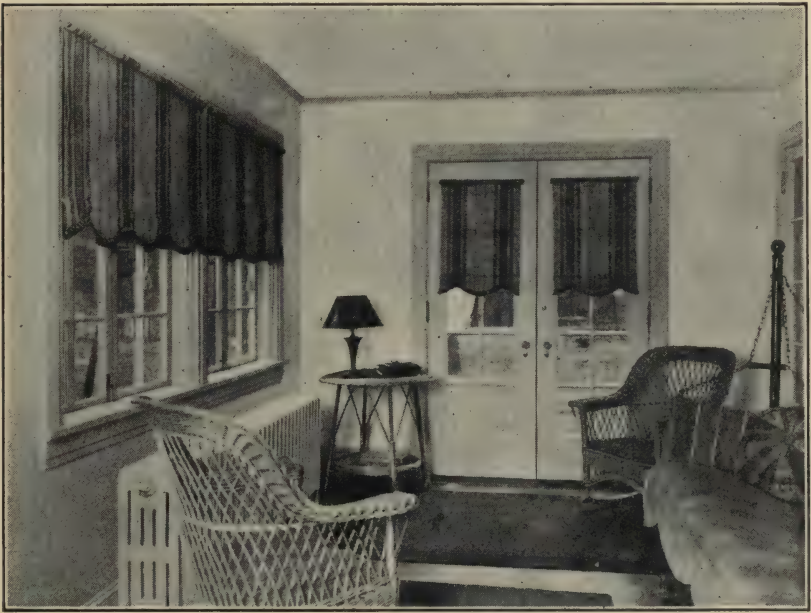


FIGURE 9.—Awning cloth shades for the sun room

bing a piece of fabric between the hands and holding it before a light where any breaks or splits can be seen, wearing quality can be judged somewhat. A good shade should withstand pinholing, cracking, and breaking when folded or in use. The fabric should be evenly woven and free from imperfections, and the entire length of every shade should be examined carefully before purchase. If shades are not cleanable, they must soon be discarded. A simple test is to place a sample flat on a table and scrub it with warm suds. Resistance to sunlight may be tested to a slight extent by exposing a sample at a window for a week or 10 days. A fabric that shows signs of burning or fading in this time is an inferior quality and a poor buy.

The selection of the roller is also important. One at least an inch in diameter is usually the most satisfactory. Every shade should roll and unroll easily. The spring in the roller should be strong enough to withstand ordinary usage and be adjustable for the tension

required. It should catch readily at every turn of the roller and release easily when pulled.

Shades should harmonize with the color and general style of the house and should give a uniform appearance from the exterior, except perhaps in the sun room. On the interior, the shades should blend unobtrusively with the window casing. Duplex shades with a different color on each side eliminate the necessity of having them uniformly colored in all rooms. Those with dark color on one side are preferable for bedrooms because they transmit less light than those of light color. If desired combinations are not obtainable in duplex shades, two may be used, the decorative one on the inside and the plain one next to the window, to keep the effect uniform from outside.

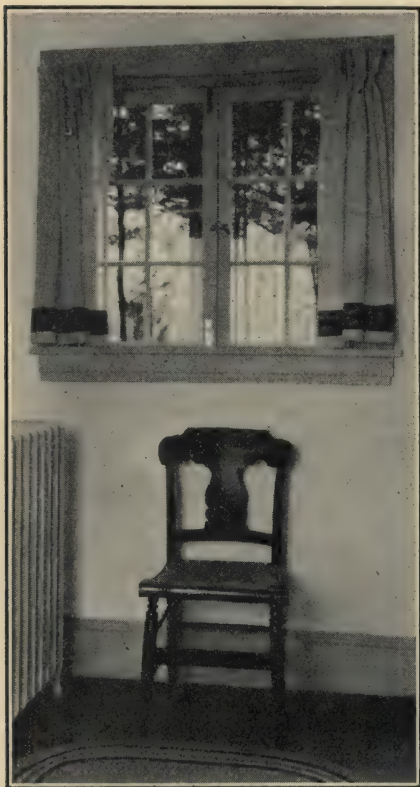


FIGURE 10.—Unbleached lawn draw curtains with a colorful border at a hall casement window

CURTAINS FOR SPECIAL TYPES OF WINDOWS

GROUP AND BAY WINDOWS

Modern architecture uses groups of two, three, or more windows. Appropriately curtained, these are a decorative asset to any room. Group and bay windows are interesting in themselves and should be curtained in the simplest possible manner. Draw curtains in lovely textures make a dignified and charming treatment. If more color or a more elaborate arrangement is desired, a valance with side draperies may be used with glass or draw curtains. Group windows separated only by the casing are usually curtained as a single unit. Side draperies alone may be hung at either end of the group or they may be combined with a continuous valance.

When the lowering effect of such a valance is undesirable, a painted pole, a wrought-iron rod, or a cornice board may be substituted. In groups of several windows, as in the sun room, side draperies may be hung over the mullions which separate the windows. (Fig. 14.) Too many vertical lines may disturb the proportions of the room and this treatment must be used cautiously.

Windows placed close together yet separated by wall space also may be treated as one unit if that space is a mere strip. When this treatment is used, the drapery material must blend closely with the wall paper, so that the large mass needed to cover the wall space will not disturb the balance of the room. A mirror, a small table and

a lamp, or a vase of flowers may be placed between the windows to form a group when they are too far apart to be treated as a single unit.

CASEMENT WINDOWS

Draw curtains are especially appropriate for casement windows, with or without side draperies and valances. (Figs. 4 and 10.) If the casement opens in, the valance must be placed high enough on the wall so that the window, as it swings in, just clears the edge of the valance.

Glass curtains are generally unnecessary on casement windows unless the outlook is unpleasant. If used on casements opening in, the curtains may be shirred over a rod at the top and bottom of the frame, or hung with rings at the top, so that they swing with the window. Glass curtains are not desirable on windows that open out, and if used they must be hung on the casing, since they would be ruined by the weather if attached to the window frame.

ARCHED WINDOWS, DOORS, AND SIDE LIGHTS

Arched windows are the most difficult of all to curtain. Shaped rods made to order are necessarily expensive, but some arched windows may be curtained without them. One way is to place screw eyes in the framework of the arch, 2 or 3 inches apart. The curtains are then shirred and run on a cord. A tape

is stitched to the back of the curtain to hold this fullness in place and to carry hooks that fit into the screw eyes. With this method, effects as in Figure 11 A, B, and C, may be obtained. Another and even simpler method is to ignore the arch and curtain it as a rectangular window with a valance that conceals the arch.

The curtaining for glass-paneled doors and side lights should be simple. Usually net, silk gauze, marquisette, or material of that type is shirred on rods at the top and bottom. For a more elaborate effect weighted fringe may be put on the bottom and the curtain allowed to hang loose. Natural-colored linen with insertions of filet or other heavy lace mounted on a roller is dignified and charming for a door panel in a formal city house.

Side lights, transoms, and fanlights should be curtained to carry out the same scheme used on the door. The side lights should duplicate it exactly. The transom should be covered by the same material drawn on rods top and bottom, regardless of the way the door curtain is hung. A fanlight is curtained like an arch. (Fig. 11, A or B.)

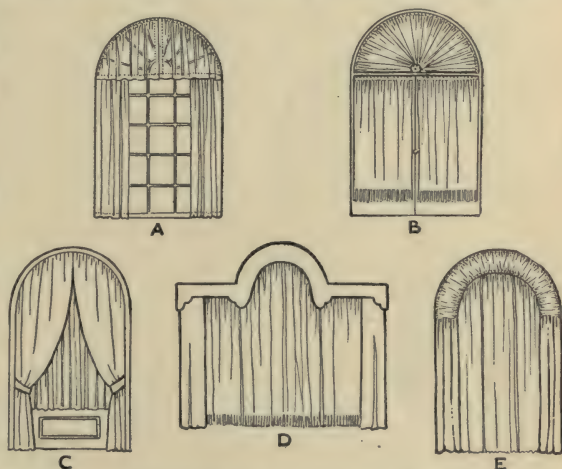


FIGURE 11.—Curtains for arched windows. A and B, suitable treatments for the fanlight over doors or windows. The short curtain in A is shaped at the top to match the curve of the window. The fan in B is made from a straight piece shirred to fit the arch, drawn in tightly at the center, and finished with a rosette of the material. C and E, elaborate curtains for which curved rods are almost necessary. D, a curtained Palladian window

On French doors between living rooms the same fabric used in glass curtains at the windows may be Shirred at the top and bottom on small brass rods and tightly stretched over the glass so that the curtains fall in well-defined plaits, or it may be allowed to hang loose at the lower edge like a curtain. If there are no glass curtains, net, gauze, case-ment cloth, pongee, or similar fabrics may be used.



FIGURE 12.—Floor-length side draperies with a fitted valance and ecru marquisette glass curtains, for the large living room

French doors that lead into sleeping rooms must be screened more completely. Sheer curtains may be mounted on either or both sides of the door with, if need be, a plain or decorative shade underneath.

CURTAINS FOR DIFFERENT ROOMS

Curtains for different rooms, like clothes for different occasions, are most successful when chosen to fit into a particular setting. Many people prefer the simplicity and economy of but one curtain at a

window and the same kind for all rooms. The slight loss in individuality is offset by the harmonious and unified appearance of the windows from both outside and inside. In country homes and small houses, colonial ruffled tie-back curtains or draw curtains are effective throughout the house.



FIGURE 13.—Double Dutch draw curtains break the lines of long narrow windows and allow light and ventilation through either sash

In some regions curtains are dispensed with during hot weather. Silks are rotted by the sun, and heavy draperies make rooms seem stuffy; but cretonnes, printed linens, glazed chintzes, and novelty cottons are suitable the year around. If winter draperies must be taken down, it seems inexcusable to leave the windows bare in summer

when curtains are especially useful in subduing light and keeping out dust. With simple furnishings, even cotton crêpe or gingham, will relieve the stark bareness of uncurtained windows. Or awning striped linen or flowered chintz mounted on rollers makes a decorative and serviceable window treatment for summer. (Figs. 9 and 16.)

LIVING ROOM

The living room is the place where family and friends gather. Since draperies and accessories are largely responsible for creating a restful, cheery, homelike atmosphere in this room, they should be dignified yet simple enough to make everybody feel at home. (Figs. 4, 5, 12, and 14.) Extreme and faddish window decorations are out of place in



FIGURE 14.—Soft translucent fabric arranged in straight draperies and gathered valance makes this group of windows a decorative feature of the living room. Rather wide but inconspicuous stripes of two colors in the fabric emphasize the vertical lines and prevent the group of windows from appearing too broad

a room that reflects the interests and furnishes the background for so many people.

Warm colorful cretonnes and patterned fabrics are generally a good choice for the living room, but the design should have dignity. (Figs. 4 and 12.) Patterns with roses natural enough to pick and birds ready to burst into song grow tiresome when looked at month after month. Nor is the extreme formality of damasks, brocades, and tapestries appropriate in the average home. Deep-toned richly patterned cretonnes or hand-blocked linens with backgrounds to match the color of the walls, are far more pleasing, and there are innumerable designs that express individuality. Pronounced stripes are suitable though rather severe for the living room, but are sometimes useful in giving definite heightening or broadening effect. Although plain materials may border on the commonplace, they are sometimes

a wiser choice than highly figured fabrics. Portières should be of the same material as the side draperies or of plain material the same color or slightly darker than the walls. The fabric should be reversible, or the portières should be lined so that they will be equally pleasing from both sides.

DINING ROOM AND SUN ROOM

If the dining room connects with the living room a more spacious effect is gained in the small home by using the same kind of draperies in both rooms. Or, in order to give an atmosphere of freedom and gaiety that many enjoy in the dining room, animated designs may repeat the colors predominating in the living-room curtains.

If there is a breakfast room or a sun room, it may be even more gay and refreshing than the dining room. Colors there may be almost at their fullest intensity. Materials appropriate for the breakfast room or alcove are checked or striped gingham, English print, voile, dotted swiss, cretonne, or muslin banded with color. For the sun room particular care should be taken to select colors and fabrics that will not fade or be affected by the intense light. Strongly patterned cretonne and vivid awning stripes look well and are effective, but to avoid the unpleasant possibility of faded colors many people prefer to use natural-colored curtains.



FIGURE 15.—Osnaburg dyed the boy's favorite color and banded with boldly patterned cretonne makes attractive and substantial hangings for his room

BEDROOMS

For inexpensive curtains in the bedroom, daintily colored, dotted swiss is attractive, and unbleached muslin bound, banded, or appliquéd with color is always good. Appliqué or embroidery motifs may be taken from cretonne or from commercial transfer patterns, but they should be used with discretion to avoid a spotty effect. Unless the same kind of window treatment is used throughout the house, personal preferences should be consulted in selecting bedroom curtains.

Simple lines, rough textures, and decided colors appeal more to men and boys. (Fig. 15.) Floral motifs often seem feminine to them,

and they are more likely to be attracted by stripes, checks, or some of the modernistic geometric designs. Side draperies of osnaburg, monk's cloth, cotton homespun, rep, or hand-blocked linen combined with marquisette or theatrical-gauze glass curtains satisfy the masculine taste; and oftentimes draw curtains of plain-colored mohair or linen-crash alone are sufficient.

The young girl's room should also express her individuality. If she is a hearty out-of-doors girl who enjoys the same things as her brother, she wants strong colors, straight lines, and vigorous patterns. But if she likes ruffles and dainty colors, she will prefer filmy curtains



FIGURE 16.—Ruffled tie-back curtains of cream voile over a glazed chintz shade are suitable for a girl's room

of dotted swiss, or-gandie, voile, marquisette, or net. Curtains of these materials may be hung straight and used alone or with a valance and side draperies of cretonne, poplin, or glazed chintz. Instead of side draperies interesting color effects can be obtained by hanging two thin fabrics of different hue together. Thus blue hung over rose gives a mauve effect, and blue over yellow appears green.

Ruffled curtains are informal and particularly suitable in the bedroom. They may be used alone with tie-backs of the same fabric, combined with side draperies and a valance, or crossed in the middle. When

hung over shades of glazed chintz they provide charming variety. (Fig. 16.) Cream color is generally best, though white curtains may be used with white woodwork. In any case, curtains and ruffles should match in color. Sometimes colored bindings which match figures in the curtains are effective.

The nursery needs plenty of sunlight and air. Sturdy, simple curtains with rather bright colors are best. English prints, gayly checked gingham, brightly colored Japanese crêpe, and appliquéd unbleached muslin offer many possibilities. Suggestions for decorative motifs may be taken from the child's favorite story book. Glass curtains may be omitted entirely, but because of the child's daytime nap some means of excluding light is necessary. Duplex shades, dark on one side, or lined draw curtains are satisfactory.

The adult's room should have dignity and repose. If occupied by two persons, an attempt to satisfy both should be made. This

often means a compromise toward something less personal. A man usually prefers dark polished wood to pastel painted furniture for his room. This implies that he would also enjoy substantial curtains more than he would pale colors and delicate fabrics. The India print in Figure 13 suggests the color scheme of red and blue for this room. The curtains are the same color as the background of the print, and the soft rich colors are repeated in the rugs.

KITCHEN

It is unnecessary to leave the kitchen windows uncurtained even though the view is especially pleasant, or the room is rather dark.

Side draperies of gingham, glass toweling, muslin, or some other durable material easy to launder, make the work room more livable. A valance, if used, should be reduced to a mere ruffle so that it will not interfere with ventilation. (Fig. 17.) If kitchen windows must have glass curtains, a thin material, banded with bright color, or appliquéd with a few motifs may be used and side draperies omitted. At the standard double-hung window, the so-called Dutch or double-sash curtains shirred on rods are practical and make it possible to regulate ventilation easily.



FIGURE 17.—Kitchen curtains of unbleached muslin and checked gingham. The valance reduced to a double ruffle permits ventilation at the top of the window

METHODS OF MAKING AND HANGING CURTAINS

An accurate though quickly made drawing of the window is the greatest help in deciding which of a number of curtain arrangements to choose, and it is practically a necessity in calculating the exact quantity of material to buy.

Use a yardstick or ruler for taking measurements; a tapeline may stretch and cause inaccuracies. As the measurements are taken, write them down and make a drawing of the window to scale. In making this drawing, if 1 inch is used for each foot, a window 72 by 36 inches would be drawn 6 by 3 inches. Make a number of tracings of this drawing and on them sketch in and study the lines for various

types of curtains. Illustrations of window treatments clipped from magazines and advertising circulars offer many suggestions. As a help in deciding which to choose, calculate the quantity of material needed. Write down the needed amounts, not forgetting allowance for shrinkage and for hems, on the same paper with the sketch and window measurements, so that all the information concerning each window is together. In calculating the quantity of a boldly patterned material, make sure that the patterns balance on both sides of the window. If two or more windows are to be curtained, thus calling for four or more curtain lengths, experiment with the goods while in the bolt so as to avoid waste. Often it will be found that though the first and second lengths will not match, the first and third will, with little loss.

TYPES OF CURTAIN RODS AND VALANCE BOARDS

Personal preference and the type of curtain determine the kind of curtain rod to choose. Solid round rods that fit into sockets screwed

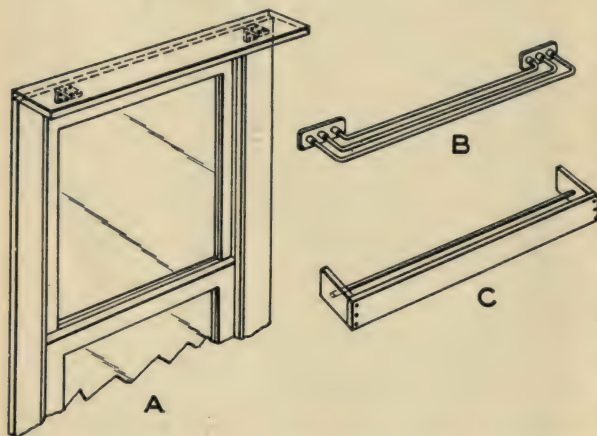


FIGURE 18.—Fixtures for hanging overdraperies: A and C, types of valance boards; B, a triple rod bracket for draperies, glass curtains, and gathered valance

to the inner side of the casings are best for glass curtains that are hung with draw curtains, side draperies, and a valance. But if glass curtains are used alone and cover the casing, flat curved or round rods may be chosen. When the windows are unusually wide, the rod may need a support to keep it from sagging.

Flat or round rods with extension ends may be used when glass curtains, side draperies, and a valance are hung at the same window. (Fig. 18, B.) Casings should be wide enough to fit easily over the rod. Rings, hooks, or pin attachments may be used instead of casings to suspend the curtain from the rod and are essential when the curtains are plaited.

Improvements in rods are made from year to year, and styles in curtains change. Before purchasing rods it would be advisable to see the newest kinds on the market, compare the relative merits of all types, and then choose the one that best meets the requirements of the particular window treatment desired.

Sometimes a decorative pole and rings sewed to the top of the curtain are substituted for the valance. (Figs. 4 and 8.) These may assist in carrying out the color scheme and are effective with cretonnes, hand-blocked linen, or striped novelties.

All types of valances, except possibly the shirred valance, hang better when supported by a valance board. The simplest form is a wooden shelf, 3 or 4 inches deep and $\frac{1}{2}$ inch thick, which rests on the top of the window casing. Such a valance board may be nailed

or screwed into place, or if there is no ledge at the top of the window, it may be held in place by a pair of angle irons. (Fig. 18, A.)

A second type of valance board (fig. 18, C) is 4 to 5 inches wide, with a piece 3 inches long nailed at right angles to each end. A rod for the side draperies may be put inside the 3-inch returns. The board is held in place by screw eyes in the end pieces which catch into hooks in the extreme outer part of the window casing. This type is preferable for a fitted valance, and is called a cornice board when decorated or made from a decorative molding and substituted for a valance.

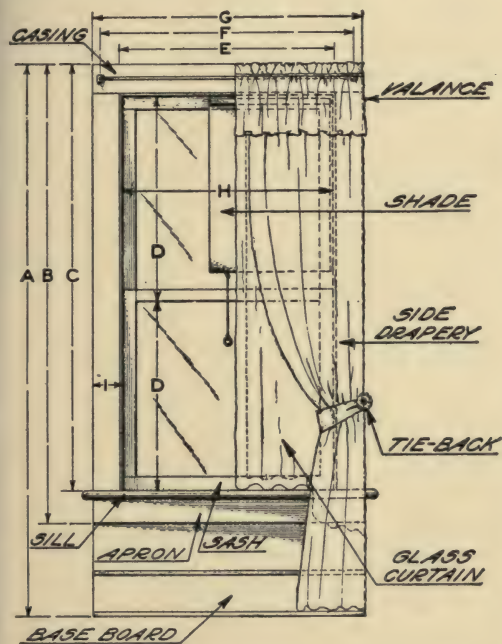


FIGURE 19.—Double-hung window drawn to scale, showing the lines on which measurements for different types of curtains should be made: A, side draperies in a formal room; B, side draperies and draw curtains for less formal effect; C, glass curtains and draw curtains; D, draw curtains and preferred length for glass curtains; E, width for glass curtains and draw curtains when the length is measured on D; F, usual length of rod; G, width used for valances and all curtains hung outside the casing; H, shade hung inside the casing; I, face of the casing

GLASS CURTAINS AND DRAW CURTAINS

CALCULATING MATERIAL NEEDED

Measure for the width of glass curtains on the trim nearest the glass (fig. 19, line H) and on line D for their length. They should be just long enough to escape the sill. If they are to be hung without overdraperies and the casing is not attractive, take the measurements on lines G and B. For double Dutch curtains measure on line D; the measurement for the top curtain is to the bottom of the meeting rail, and for the lower one from the top of the meeting rail to the sill.

Draw curtains may replace side draperies or they may be used in combination with them. If used alone, measurements should be taken as for side draperies; the width is taken on line G so as to cover the entire casing and draw curtains usually extend to the lower edge or the apron.

When hung under side draperies, they need not cover the entire window casing. In that case the width may be measured on line F, and they may extend only to the sill. Sometimes they are hung entirely within the casing. Then the width is taken on line E, and they must necessarily end at the sill.

Hems $1\frac{1}{2}$ to 2 inches wide on the inside and lower edges and $\frac{1}{4}$ inch wide on the outside edges are in good proportion for glass and draw curtains. Handkerchief hems, which derive their name from being made an equal width on all four sides of a curtain, are used occasionally to add to the decorative effect when there are no overdraperies. When either glass or draw curtains are used alone, a heading at

the top makes a neater appearance, and 2 inches must be allowed for it. If side draperies or a valance is used, this allowance is omitted and only $\frac{1}{4}$ of an inch is added for the casing. French headings (page 23) used on draw curtains require an extra 3 to 6 inches. These headings are made double and are $1\frac{1}{2}$ to 3 inches wide when finished. An additional allowance of 2 inches or more should be made for shrinkage in cotton fabrics. A common rule is to add 9 inches to the desired length of the finished curtain. This gives sufficient material for shrinkage, hems, and heading.

For example, here is the way to go about calculating the yardage needed to curtain one window:

	Inches
Window, height (fig. 19, line D) -----	72
Window, width (fig. 1,9 line H) -----	31
For 100 per cent fullness:	
Two lengths 36-inch material -----	144
Double hem on bottom, $1\frac{1}{2}$ inches deep (3 inches each) -----	6
Heading and casing ($3\frac{3}{4}$ inches each) -----	$7\frac{1}{2}$
Shrinkage, 2 or more inches -----	4
Total -----	$161\frac{1}{2}$ ($4\frac{1}{2}$ yards)

MAKING GLASS AND DRAW CURTAINS

Measure and check each curtain length before cutting into the material. If the weave permits, draw a thread and follow this line in cutting. Trim off all selvages, and put in side hems first, then top and bottom hems. Make all turnings the width of the hem so that raw edges will not show when light shines through. (Fig. 20.) If the material has figures in it, match them up in all the thicknesses if possible. Turn the allowance for shrinkage into the bottom hem unless it looks too bulky; or take it in as a tuck just below the casing if the curtain is to be shirred on a rod; or turn it into the French heading (p. 23). In the latter case, all the heading must be taken out when the curtain is let down. Irregularities in length can sometimes be corrected by taking an inconspicuous tuck at the top or by moving the rings, but it is far better to make curtains so accurately that they will need no such adjustment. Hems put in by hand do not draw and they look better than those stitched by machine.

Weighted tape tacked in the bottom hem, tends to prevent curtains from blowing out open windows and makes them hang in more even folds. Fringe is a popular finish for glass curtains and may be used instead of weights. It may be placed on the edge of the curtain, but a more desirable plan from the standpoint of wear and beauty is to set it full depth up on the curtain.

To make the ruffles $2\frac{1}{2}$ to 4 inches wide used on colonial tie-back curtains (fig. 16), cut and join strips of material until there is one and one-third times the total length and width of the curtain. Finish the ruffles with a narrow hem made with the narrowest hemmer attachment, a machine-picoted edge, or a narrow colored binding. Join the ruffle to the curtain with a French or a lapped seam. A diagram for drafting shaped tie-backs is shown in Figure 22. The length can be adjusted to the particular curtain, and the edge may be finished with a ruffle or braid. Instead of tie-backs, rosettes, bows, or bands may be used.

FRENCH HEADINGS AND BOX PLAITS

French headings, sometimes called pinch plaits, are grouped plaits and are attractive in almost all materials. (Fig. 21.) They form well-spaced folds in the fabric as it hangs and give a professional touch to glass curtains, draw curtains, valances, and side draperies.

For a French heading in draw curtains fold a double hem according to Figure 20. If the material is very soft a piece of Holland cloth or crinoline the exact width of the hem folded into the top hem gives the necessary stiffness. Measure the width of the hemmed curtain. From this measurement deduct the number of inches to be covered by the curtain when hung (one-half the width of the window), plus the distance from the curve of the rod to the wall, plus $1\frac{1}{2}$ inches for the curve and one-half inch for a lap in the middle. For example, if the material measures 34 inches after all edges are finished and is to cover a space of 15 inches, and if the distance from the straight portion of the rod back to the wall is 3 inches, subtract 15 inches plus 5 inches, or 20 inches, from 34 inches. The remainder, 14 inches, should be equally divided into the plaits. (Fig. 21.) One group must be placed $1\frac{1}{2}$ to 2 inches from the inside edge of the curtain and another at the point where the rod curves. The others may be evenly spaced between these two. The groups may be from 3 to 5 inches apart. In the case described, three groups of plaits, with about $4\frac{1}{2}$ inches for each, will distribute the fullness and make the curtain fall into attractive folds.

Having located the position for each plait, pin, baste, and stitch it down 4 to 6 inches from the top, depending on the weight of the material. (Fig. 21.) Divide each wide plait into three small ones and

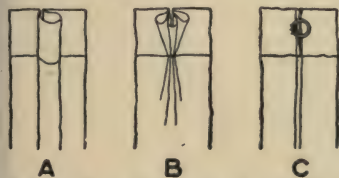


FIGURE 21.—One method of making a French plait. A, first large tuck; B, tuck divided into three parts pinched in, and sewed down; C, ring sewed to back ready for hanging

sew them down tightly about 3 inches from the top with strong thread of matching color. In heavy materials it is difficult to divide the wide plait into smaller ones, and another method is preferable. Locate the position of each plait. Divide the entire space into thirds and mark with pins. Thus if 6 inches is allowed for each group, the pins will be 2 inches apart. Turn to the wrong side, and fold the material along each line of pins so that there are four folds. With

a heavy linen thread catch the second and third folds together about 2 inches from the top. Starting at the top, sew the first and fourth folds together for about 6 inches. This gives the same effect as is obtained in thin materials when the first method is used. Sew rings to the back of each plait near the top so that the bottom of the curtain will hang exactly to the line intended and so that the rings will not show at the top.

If box plaits are desired, after making the first wide plait for a French heading flatten the wide plait out instead of pinching it into several small ones. Catch each box plait down across the back.

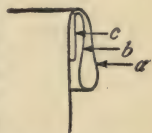


FIGURE 20.—Method of turning curtain hems: a, single turn the depth of the hem; b, the turn under the full depth of the hem; c, allowance for shrinkage

MOUNTING DRAW CURTAINS

The equipment needed for draw curtains is a smooth round or flat rod that fits securely into a socket at each end, rings large enough to slide easily on the rod, a single and double pulley, curtain cord enough to cross the width of the window twice and to leave ends long enough to be reached, and a pair of weights for the ends of the cord. (Fig. 23.)

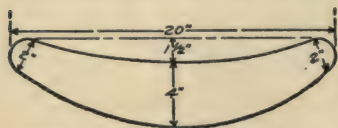


FIGURE 22.—Draft for a shaped tie-back

methods of attaching the curtain to the rod. For lightweight glass curtains sew rings to the back of each plait near the top (fig. 21, C) or at intervals of 4 inches and about 1 inch from the outer edge. Although the rod must be taken down each time the curtains are laundered, it is not difficult to manage as the curtains are not bulky. For heavy side-drapery materials such as terry cloth, monk's cloth, or velour, French heading hooks instead of rings may be sewed to the back of each plait.

The manner in which the curtain is attached to the rod does not affect the method of threading the rings. To thread up a curtain that has the rings sewed to it, place the rod and curtain on the table so that the rod is on top. Slip all the rings but one at each outer edge on to the rod. Clamp the pulleys close to the end, leaving just room enough for the end rings and for the rod to fit into the socket. Pull the two center rings (fig. 23, *b* and *c*) to the exact center of

The types of pulleys, rings, and rods change from year to year, and some kinds are more suitable to one fabric than another.

Before mounting, the fullness in the curtain is sewed into plaits so that the space will just be filled. There are two

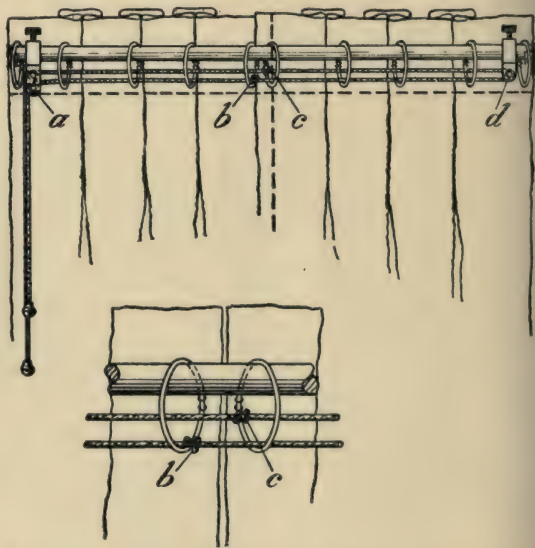


FIGURE 23.—Method of threading a draw curtain: Thread cord through pulley *a*, knot in center ring *b*, thread through single pulley *d*, and knot in center ring *c* before returning it to double pulley *a*

the rod so that the curtains lap about a half inch. Thread one end of the cord through one side of the double pulley (fig. 23, *a*), run through the rings, and knot firmly at *b*. Then thread the cord through the rest of the rings, through the single pulley, and back through the same rings to *c*, and knot again. From *c* thread the cord through the remaining rings to *a* and through the double pulley. Cut the cord that was last knotted at *c* a foot longer than the other and attach a weight to each end. Slip the two remaining rings on to the rod and fasten it in the sockets.

For a curtain with the French heading hooks, the method of threading the rings is exactly the same. After the rod and rings are in place the curtain is hooked on. The curtains are opened or closed by pulling the shorter end of the cord.

SIDE DRAPERIES

CALCULATING MATERIAL NEEDED

The finished width of side draperies is calculated on line G, Figure 19. Side draperies should cover the casing and extend to the edge of the glass at least, and in short wide windows they may cover a part of the glass. The average window requires a piece of material 36 inches wide for each side-drapery length, although 50-inch material cut in half and finished with extension hems will oftentimes be wide enough. Draperies that are skimpy are not attractive. The length may be to the apron (line B, fig. 19) or to the floor (line A) for formal effects. The addition of 9 inches to the exact length allows 3 inches for a hem at the bottom and 6 inches for a heading at the top. Variations are possible and more accurate calculation for curtains for special arrangements is advisable. For instance, if the draperies are to be unlined, allow for a 2-inch or a 3-inch hem on the bottom and a 1-inch hem on the sides; if lined, allow for a 1½-inch turn on all sides. For French headings, or pinch plaits, 6 to 16 inches is allowed in side draperies. Six inches is the usual allowance on cretonne, poplin, and other materials of medium weight and is also correct for an ordinary casing and heading.

MAKING SIDE DRAPERIES

Use the same care and accuracy in cutting side draperies as glass curtains. Draperies are made unlined, lined, or interlined. It is often economy to line side draperies to protect the fabric from strong light, dampness, and dust. Linings also make the curtains hang better and the pattern show up more clearly. Sateen or unbleached muslin is used for lining and canton flannel for interlining.

UNLINED SIDE DRAPERIES

Trim off the selvage of the material or clip it at intervals of 3 or 4 inches. Turn a hem of 1½ inches on each side and a 2 or 3 inch hem at the bottom. If there is no right or wrong side and there is to be a band or border around the curtain, the hem may be turned to the right side and the braid or band placed over the raw edge of the fabric. Frequently this type of curtain is finished with an extension hem of contrasting material.

If there is to be no valance, fold the top into a double hem 1½ inches or wider. To take up the fullness, fold the top into French or box plaits and sew rings on the back to slide over a rod, or run in two rows of stitching to form a casing for the rod. If a valance is to be used, sew rings to the top of the curtain or make a casing without a heading for the rod.

INTERLINED AND LINED DRAPERIES

Velour, velvet, tapestry, and many other heavy fabrics require both an interlining and a lining. Remove the selvage or snip it at intervals. Spread the outer fabric right side down on the table.

Turn all four edges the width of their respective hems, miter the corners, pin, and catstitch the hems down with a long stitch. Fasten the fabric securely to the working surface and spread the interlining of single-faced canton flannel over it smoothly. Cut the canton flannel one-half inch smaller than the outside material at the top and side and an inch shorter at the bottom. The edges of the interlining are not to be turned.

Fold back the interlining lengthwise upon itself exactly along the center. With a linen thread tack the interlining loosely to the drapery fabric by taking in it stitches 5 or 6 inches apart that do not show on the right side, and catch the interlining as shown in Figure 24. The thread must lie very loosely between the stitches. If it is drawn tightly the draperies will not hang smoothly.

The number of rows of tacking is governed by the width of the material. If the material is 36 inches wide, fold it on each side of the center so that the width is divided into fourths, and repeat the tacking down these folds. This makes three lengthwise rows of tacking in all. Fifty-two-inch material requires two rows of tacking each side of the center, or a total of five rows.

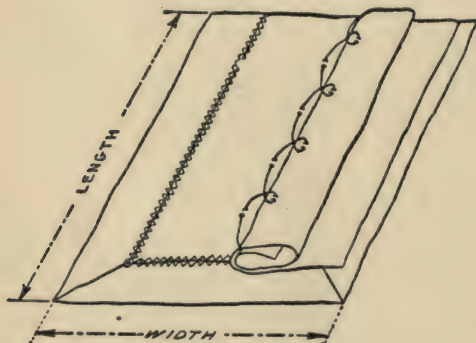


FIGURE 24.—Construction of lined and interlined draperies. The hem is catstitched down and the lining and interlining tacked by a loose stitch to the drapery material

Next smooth out the edges of the interlining and catch them to the drapery material with long stitches across the top and sides. Leave the bottom loose. Lay the lining in position and tack it to the interlining in the same way that the latter was tacked to the drapery fabric. Turn the edges under and hem or slip-stitch them to the drapery material except across the bottom, which is hemmed separately and left free. The sides may be tacked at intervals of 6

inches instead of being held tightly if the material draws. Braid or ruching sewed on the edge of the drapery should be eased on, as it will shrink more in cleaning or laundering and may cause the curtains to draw. Finish the top with a casing or with rings that slide on a rod. Sew a small brass ring to the back of the outer edge a few inches above the bottom of the drapery, to hook into a screw eye on the window casing to hold the drapery in place. Weighted tape, braid, or coat weights may be tacked into the bottom hem to make the draperies hang straight and keep them in position.

Fabrics of medium weight, such as cretonne, linen, and poplin, need no interlining, but they wear longer and hang better if lined. The method given for interlined draperies may be used by simply omitting the interlining. When a shorter method than this is necessary, trim off all selvages, cut the lining so that it will lie inside the drapery one-half inch on all edges except at the bottom. Hem the bottom of the drapery and lining separately. Then lay them together so that the lining is one-half inch above the drapery at the bottom. Turn the

side hems of the drapery over the lining one-half inch, pin carefully, turn under raw edges, baste, and slip-stitch the side hems, and the top casing, but leave the bottom free.

VALANCES

CALCULATING MATERIAL NEEDED

The basic measurement for the length of the valance is taken across the top of the window on line G, Figure 19, and the depth is approximately one-sixth the length of the side draperies. To this depth the hem, heading, and casing allowances are added. Two times the basic measurement (line G) is used for a plaited valance, and one and one-half times line G for a gathered type. The length of line G plus a 3-inch return on each end is sufficient for a fitted valance. (Fig. 25, A and B.)

With the exception of the straight gathered kind, valances are always lined and in many cases interlined. Buckram or canvas is the foundation material for fitted valances, and they are interlined with canton flannel to keep the light from showing the pores of the buckram and to make the effect a little less stiff. All valances, except the fitted, may be hung on separate rods with extension ends or hooked on to the rod that carries the side draperies. As a rule, separate valances should not be run on the same rod with the side draperies. Fitted or plaited valances hang and look better if they are tacked or snapped on to valance boards.

MAKING VALANCES

GATHERED VALANCES

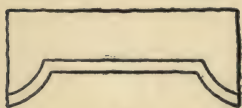
Cut off the necessary length of material, and in the sides put a hem the same width as that on the outer edges of the side draperies. Turn and sew a 1½-inch hem in the lower edge, and fold the 6 inches at the top into a double hem and sew it down. Run in another parallel row of stitching to form a casing for the rod. Or instead of running the valance on a rod, three or four cable cords may be run in to form shirring and the valance hung from the rod by rings. Another variation is to stitch a heading and casing into both the top and bottom of the valance and run rods in each. Valances of scrim or net that accompany colonial tie-back curtains may have the heading turned and stitched in one with the curtain so that they may both be run on the same rod and have their fullness evenly adjusted.

FITTED VALANCES

Measure off the extreme width of the window on a heavy piece of paper. Fold it in the middle and draw one-half of the pattern for the valance. Several designs that may be used are shown in Figure 25. Cut this out with a 3-inch allowance on each end to extend back to the wall. Unfold, fit it into place, and study the proportions of the valance to be sure they are in harmony with other parts of the window treatment and that the 3-inch allowance is sufficient. Make any changes necessary in the pattern, then pin it to buckram, and cut without a seam allowance. Use the buckram as a pattern, and from this cut out the canton-flannel interlining, allowing a 2-inch extension on all sides. Turn the 2-inch allowance over the edge of the buckram,

slash where necessary to make it lie smoothly, pin, and tack into place. Spread the drapery fabric smoothly on a table with the right side down. Place the flannel-covered side of the buckram next to the wrong side of the fabric and pin the two together. If the drapery material is figured, see that the motifs come in the right place. Cut the drapery fabric, and again allow 2 inches for hems. Turn this allowance over the edge of the buckram, and clip when necessary to make it fit smoothly around the curved edges. Pin and sew to the buckram with long catstitches. Sew on braid or any other trimming.

A strip sewed to the top of the valance is a convenient means of attaching it to the valance board. For this, use a piece of the lining material 8 inches wide and 2 inches longer than the length of the valance. Fold it in fourths lengthwise, so as to make the strip 2 inches wide. Turn 1 inch in at each end and sew the strip to the buckram side of the valance; this allows $1\frac{1}{2}$ inches to extend beyond the edge.



A



B



C



D



E



F

FIGURE 25.—Types of valances and headings. A and B, shaped valances; C, plaited valance; D, French plaits; E and F, variations of double box plaits

Cut out the valance lining, with a 1-inch allowance for seams. Turn this under; pin and slip-stitch it down on all sides. The valance is now ready to be attached to the valance board.

It may be nailed into place, or a tape with snap fasteners may be tacked to the board and the other half of the tape stitched to the band sewed to the top of the valance, so that the two snap together. Still

another method is to sew rings to the tape and catch them over tacks or hooks about $1\frac{1}{2}$ inches apart near the upper edge of the board. Before the valance is put up, measure the exact width of the window off on the valance and bend back the ends or returns, but do not form a hard square crease.

SHADES

Although it is generally more satisfactory to have shades made by a shade specialist or to buy those carried in stock, it is sometimes necessary to make them at home if unusual types of shade cloth are desired.

Measure for a shade according to the place where it is to hang. It may overlap the casing; or if the casing is at least 2 inches deep, the shade may hang within it. The brackets may be mounted on the casing just outside the sash run and just above the sash-weight pulleys. When hung in this way shades do not interfere with curtains, and more attractive arrangements are possible. Shades hung to overlap the casing exclude more light and wear less on the edges. Brackets are then placed on the face of the casing.

All measurements must be accurately made. The finished-length measurement should be about 12 inches greater than the distance from the bottom of the top casing to the sill to allow for a hem and enough to wrap around the roller and give leeway in pulling up or down. For shades hung inside the casing, the roller must exactly fit between the casings. Thus for a window that measures 30 inches between the casings the roller measurement would also be 30 inches. But if the shade overlaps the casings the roller measurement must be 4 inches greater than the distance between, or 34 inches. In either case the shade cloth is about $1\frac{1}{2}$ inches less than the roller measurement.

When the material is exactly the right width the selvage need not be removed. If the cloth is too wide, such fabrics as glazed chintz and oilcloth may be cut the exact width and the edges left unfinished. Linen or unglazed cloth will ravel, and 2 inches must be allowed in the width for flat hems. On cloth that is too narrow, a lapped seam, with the edges left raw, will make the flattest joining. It may even be wise to have a shade maker sew the seams, for shades will not roll well if they are bulky.

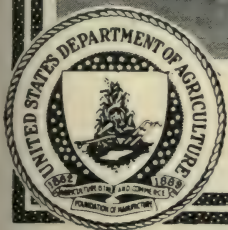
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U. S. DEPARTMENT OF
AGRICULTURE

FARMERS' BULLETIN No. 1634

GROWING
SWEET CORN
for the
CANNERY



U. S. DEPARTMENT OF AGRICULTURE
INVESTMENT REPORT

SWEET CORN, which ranks among the three most important canned vegetable commodities, is produced commercially in several of the Northern States. It is a tender annual plant easily injured by frost and will not withstand excessive heat. Its production is therefore limited to those sections where there is a minimum frost-free season of 85 to 120 days.

The successful production and canning of sweet corn on a commercial scale requires favorable soil, climatic and economic conditions, and close co-operation between the producers and the manufacturers.

Husks and other wastes from sweet-corn canning are of considerable value for feeding. The stover, with the small ears remaining on it after the harvest of the canning crop, adds materially to the grower's income from the crop.

GROWING SWEET CORN FOR THE CANNERY

By J. H. BEATTIE, *senior horticulturist, Division of Fruit and Vegetable Crops
and Diseases, Bureau of Plant Industry*

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IMPORTANCE AND DISTRIBUTION OF SWEET-CORN GROWING FOR THE CANNERY

Sweet corn, which ranks among the three most important canned vegetable commodities, is produced in commercial quantities in several States in the northern half of the United States. Its production is highly developed in Iowa, Illinois, Maryland, Ohio, New York, Indiana, and Maine, and to a lesser extent in Minnesota, Wisconsin, Michigan, Nebraska, and Pennsylvania. Production of this crop has varied considerably in recent years. The production in 1933 and 1934 was approximately 395,000 tons and 495,000 tons, respectively, while the average production for the years 1928 to 1932 was 628,000 tons. The acreage in 1933 and 1934 devoted to the crop was approximately 200,000 acres in 1933 and 287,000 acres in 1934, while the average for the years 1928 to 1932 was approximately 314,000 acres.

CLIMATIC REQUIREMENTS

Climatic and soil conditions have influenced to a large degree the growth of the sweet-corn canning industry in the areas mentioned. Sweet corn is a tender annual plant, easily injured by frost, and one that will not withstand excessive heat. This fact limits its produc-

tion to those sections where there is a minimum frost-free season of from 85 to 120 days within which suitable varieties may be grown. The spring months should be sufficiently warm so that the corn will make a rapid and uninterrupted growth; but excessively hot weather during the summer months, especially when accompanied by drought, may cause premature ripening and low yields. Cool summer weather has a tendency to retard the ripening of the kernels, extending the period through which the ears are in edible condition. An average annual rainfall of about 40 inches, properly distributed throughout the year, will supply enough water for bringing the crop to the proper stage of maturity for canning.

ECONOMIC CONSIDERATIONS

The canning of corn economically and in conformity with modern standards of quality requires expert supervision and a large investment in factory equipment. This necessitates operations on a rather large scale if the enterprise is to be profitable. With a large investment in equipment and the need for employing a great deal of labor, factory operation is costly. If a corn canner is to operate his business successfully, he must be able to obtain an adequate supply of high-quality corn at prices that will leave him a reasonable margin of profit after he has disposed of his pack upon markets in which competition is keen and prices are often unstable.

It is obvious that if the farmer is to profitably grow corn for the cannery, he must receive a reasonable return for his labor and upon his investment in land and equipment.

These conditions preclude the successful operation of a corn-canning establishment in a region where good yields cannot be obtained by the farmer. Canner and farmer are interdependent and will succeed or fail together. Operations should be attempted only in regions where good yields can be obtained on lands of medium value. An adequate acreage must be available to yield a sufficient quantity of corn to keep the factory in full operation for a reasonably long canning season. Moreover, climatic conditions must be such that corn of uniformly high quality can be delivered.

Sweet corn may be successfully produced in growing seasons too short for the maturing of most varieties of field corn. It fits well into the farm-crop rotation and occupies the land a shorter time than certain other crops, giving an opportunity for an increased use of green manure and cover crops. Since cannery corn is usually grown under contract and delivered as soon as harvested, marketing and storage problems are eliminated. The stover and cannery wastes afford a supply of succulent roughage for livestock at a period when other sources of such feed are often scarce.

METHODS FOLLOWED BY CANNERS TO PROVIDE FOR SUPPLIES OF SWEET CORN

In the Eastern States most of the sweet-corn crop is raised by numerous growers in small fields of a few acres each, whereas in the Corn Belt there are factories each of which operates several thousand acres devoted mainly to sweet corn. Probably three-fourths of the green corn packed is grown under contract by individual growers.

Contracts are made some months before planting time, sometimes on a sliding scale, but oftener at a stipulated price per ton for a given variety. The tonnage may be based upon corn in the husk or upon husked corn. The variety and the acreage are specified for each grower, sometimes with a clause relative to separate plantings at stated intervals. The seed is usually furnished by the company. The grower usually agrees to separate the different varieties of sweet corn from one another or from field corn by a stated distance, to plant carefully, to cultivate thoroughly, and to keep the fields free from weeds until the crop is ready to harvest. The crop must be harvested in the milk stage. The ears are snapped or cut off with the minimum amount of shank and are delivered to the factory on the same day they are harvested, before the corn has become heated or otherwise damaged. The waste products, including the husks and cobs, usually belong to the company, although some of this material may be returned to the producer for immediate feeding (fig. 1).



FIGURE 1.—Sweet-corn husks and cobs being returned to the farmer for feeding.

SOIL AND FERTILITY REQUIREMENTS

SOILS

Sweet corn is produced on soils similar to those used for field corn, but the crop is more exacting as to the conditions under which it is most successfully grown. A well-drained, medium heavy loam, abundantly supplied with organic matter, will probably give the best results. Where heavy clays are used their physical character should be improved by turning under large quantities of manure and cover crops. Moderately heavy soils are preferred, since they are more retentive of moisture and the crop is less liable to suffer from drought during the latter part of the growing season. These soils cannot be worked as early as the lighter soils, but that is no particular disadvantage, because earliness usually is not a very important factor with the canning crop.

CROP ROTATION

Crop rotation is considered essential to continued success in modern farming. It is one of the requisites for improving worn-out soils and for maintaining soil fertility. It tends to prevent the exhaustion of any one particular element of plant food, and is an aid in holding in check certain insects, diseases, and weeds.

It is impossible to suggest rotations suitable to all sections, but one that brings sweet corn on the same ground not more than once every 4 years is most desirable. Such a rotation should include a sod crop, preferably clover or clover and timothy. This combination can occupy the land for 2 years and then be followed by sweet corn. Some cover crop, such as crimson clover, may be sown at the time the corn is given its last cultivation, or rye or barley may be seeded after the corn is harvested. These are turned under the following spring before such plantings as peas or oats. A green-manure crop, such as cowpeas or soybeans, may be sown at the last cultivation of the sweet corn and turned under after harvest but before frost. In other cases a grain, such as winter wheat, either alone or with grass, may be seeded in the corn stubble. When two grain crops appear in the rotation, such as oats followed by wheat, grass seed is combined with the latter for the subsequent hay and pasturage. The rotation must be planned to suit the locality, the soil, and the general type of farming.

In certain canning-crop regions tomatoes, peas, snap beans, or lima beans, as well as corn, are grown. In such regions a rotation similar to the following is common:

First year, sweet corn followed by a rye or rye and vetch cover crop to be turned under in the spring.

Second year, tomatoes.

Third year, peas followed by beans.

Fourth year, wheat followed by grass.

Fifth year, hay.

GREEN MANURE

Rotations should include rapidly growing, short-season crops of either leguminous or nonleguminous plants that are plowed under for green manure. The legumes are an advantage in that when the proper nitrogen-fixing bacteria are present in the soil nitrogen is removed from the air under favorable conditions and is made available for plant growth. Whenever practicable the land should be protected from erosion over winter by a cover crop that may be turned under in the spring. Winter cover crops, such as rye, should be turned under before they have become tall and strawy, as material of this character, if plowed under immediately before planting, is liable to rob the crop of nitrogen. The application of succulent plant material to the soil adds organic matter, improving both the physical and the chemical character of the soil and promoting the growth of helpful soil bacteria. These crops are also an aid in suppressing weed growth.

STABLE MANURE

Heavy yields of sweet corn of high quality are secured only when the soil contains an abundance of readily available plant food. This, in part, can be obtained from stable manure, which is one of

the most valuable of all fertilizing materials. Not only does barnyard manure contain most of the food elements required by plants, but it also has a markedly beneficial effect upon the physical condition of the soil. The plant-food value of manure depends upon the source and upon the conditions under which it has been kept. Manure that has been exposed to weathering and to other unfavorable conditions may have lost the greater portion of its fertility and may be of value only for the organic matter contained. Unleached manure, therefore, is preferable because of its additional plant food.

On soils suitable for the growing of sweet corn, dressings of from 10 to 12 tons of good quality stable manure should give good results. As a rule it is most economically applied with a manure spreader. Unless the manure can be stored so that it will not deteriorate, it is better to distribute it as produced. The greatest value will doubtless be obtained by spreading rotted manure on plowed land, to be worked in by disking at the time the soil is prepared for planting. Large quantities of coarse, strawy manure should not be applied immediately before a crop is planted, but preferably should be turned under the previous fall.

FERTILIZERS

Commercial fertilizers alone are insufficient to give good crops of sweet corn. Such fertilizers should supplement rather than supplant animal and green manures. The kind and quantity to be used are dependent upon the needs of the soil and the quantity of stable manure previously applied. A sufficient quantity should be used to maintain high production, and such applications should be made before the crops show a marked reduction in yield. Each grower must determine the particular kind and the quantity of fertilizer required for the best results under his own soil conditions. In general, a fertilizer containing from 4 to 5 percent nitrogen, 8 to 10 percent phosphoric acid, and 5 to 6 percent potash will be found satisfactory. The rate of application will vary from 200 to 600 pounds per acre, taking the lower quantity when barnyard manure is used. Superphosphate (16 percent phosphoric acid) applied with manure at the rate of 50 pounds per ton of manure has given good results.

Some growers have obtained superior results by applying the phosphoric acid and the potash-carrying materials at the time the soil is prepared for planting, and then applying the nitrogenous material as a side dressing later, at the time of the first cultivation. Although this practice seems to be very desirable from the standpoint of obtaining the best growth and highest yield, it should be pointed out that some extra equipment is needed, and it involves the additional labor of going over the field to apply the material. Although attachments are available for a number of standard makes of cultivators for applying top-dressing during cultivation, it remains for the individual grower to determine whether the additional labor and expense will yield sufficient gains to make this practice profitable.

Commercial fertilizers may be applied near the row, with a combination planter and fertilizer distributor, at the rate of 100 to 200 pounds per acre at planting time, but they should not come in con-

tact with the seed. If more than 200 pounds per acre is to be applied, the excess should be broadcast and worked in during the final fitting of the soil before planting.

LIME

Sweet corn is not particularly sensitive to soil acidity, but lime may be essential to some of the other crops in the rotation. Lime frequently improves the physical texture of soils, especially those of a clay nature, and also tends to liberate through its chemical action some of the plant nutrients of the soil. If the lime requirement is satisfactory for the legumes and other crops in the rotation, soil acidity will not be limiting factor in growing sweet corn.

PREPARATION OF THE LAND

Thorough preparation of the seed bed is a very important factor in obtaining high yields of sweet corn. It influences growth through its effect upon the penetration of the corn roots, the retention and supply of soil moisture, and, to a large extent, the cost of cultivation.

There is a great diversity of opinion as to the methods to be followed in the preparation of the soil, owing for the most part to the varied needs of soils, which differ widely in their physical nature. Fall plowing of all stiff and sod land, leaving the fitting until spring, affords a better seasonal distribution of farm labor. The exposure of such plowed land during winter improves the physical condition of the soil, assists in the decay of vegetable matter, and destroys the larvae of many insects. Fall plowing may be advisable where winter washing of the soil is not likely to occur, but it cannot be practiced when the land is occupied by winter cover crops. Spring plowing may be better with the lighter soils, especially when they are well drained. The depth of plowing will depend upon the nature of the land and the previous cropping system. It is a good practice on many soils to increase the depth of plowing one-half of an inch each season until a depth of 8 to 10 inches has been obtained. In fitting the land, the top layer should be thoroughly fined by disking and harrowing to a depth of at least 4 inches, and preferably deeper if possible (fig. 2). A good seed bed must be deep, well fined, and free from lumps or clods and weeds. A detailed discussion of the preparation of the land is given in Farmers' Bulletin 1714, Corn Culture.

SEED AND SEED IMPROVEMENT

Improvement of seed sweet corn by selection and modern methods of handling has been effective in increasing the yield and quality of this canning crop. Productive seed must be (1) of a high-yielding, uniform, high-quality strain and variety, (2) well adapted to the soil and climate where it is to be grown, (3) well matured and preserved from ripening time until planting time in a manner that will retain its full productivity, and (4) free from insects and diseases.

LOCALLY PRODUCED SEED

In most localities where sweet corn for canning is grown it is possible for individual growers or associations to produce and save seed. Seed produced locally by experienced growers can be made to con-

form more closely to the particular local requirements than most of the stocks obtained from unknown sources. The use of seed grown in the immediate section may lessen the risk from certain insects or diseases that might be brought in from distant sources. Seed corn from certain other regions may mature irregularly or yield poorly because it may not be adapted to the new conditions, although this is not always true.

In producing seed for large acreages it is advisable to maintain certain seed-growing plots or fields that can be given special attention rather than to save seed from a portion of the common run of corn as grown for the cannery. In developing such a source of seed the original selections from which it is to be grown may be taken from a field grown for canning, but subsequently these selections and their progenies should be subjected to further selection to elimi-



FIGURE 2.—Disking land for sweet corn.

nate undesirable characters, and they should be reasonably well isolated from less desirable strains that might cross-pollinate them.

This further selection should include the establishment of ear-to-row tests, in which the kernels of each ear are planted in separate rows so that the performance of each ear can be noted. Seed from only the best rows is saved, and the process is continued until the most desirable strains have been found, which can then be planted in increase plots for seed production for the general crop. The stock-seed plots must be gone over carefully each year for the purpose of eliminating undesirable plants; otherwise the strain will soon revert to less uniform and less desirable characteristics.

The details of the procedure of improving seed of sweet corn are essentially the same as for field corn, although different characteristics are considered in making the selections. The methods involved are fully described in *Farmers' Bulletin 1175, Better Seed Corn*.

A more technical presentation of the subject is given in Department Bulletin 1489, Corn Breeding.¹

The selection of plants from which seed is to be saved should be made in the field at the time it is desirable to have corn of high quality available for harvest, or at the time when the plants are sufficiently mature to make the important characteristics discernible. If earliness is desired, stalks showing this character to a marked degree when compared with the average of the field should be selected; but premature ripening, which may result from injury, should not be mistaken for true earliness. Plants producing the highest yield of the best ears when growing in competition with a full stand of healthy plants are the ones to select. Other traits, such as drooping ears that shed the rain readily, ears that are borne at the proper height for snapping and also that are of a size and shape to permit efficient cutting in the factory, should be taken into consideration. From 14 to 18 pounds of corn on the ear are required to plant 1 acre. After estimating the requirements on the basis of total acreage, three or four times as many ears as are needed should be selected, so that sorting and grading of the stock can be done more carefully. The plants chosen for seed purposes should be marked with tags or pieces of bright-colored cloth so that in harvesting for the cannery these ears will be left to ripen thoroughly on the plant.

Care should be taken to harvest the seed ears before freezing weather and during a dry period, in order to prevent the reduction in vitality and productivity that follows exposure to low temperatures while the moisture content is high. Even when gathering is delayed until the stalks and leaves are dry, the ears still contain a large percentage of moisture. These ears should be placed immediately in a dry, ventilated storeroom where each ear will be fully exposed to the air. Seed sweet corn is frequently injured by heating when stored in piles. It spoils more quickly than field corn and cannot be readily cured in shocks.

It is best to employ some means for separating the individual ears. This can readily be done by stringing them together with twine, by sticking the butts on hooks made by cutting wire fencing, or by placing them on sets of wire-bottomed trays (fig. 3). Means should be provided to insure an even distribution and rapid circulation of the air and for its removal by ventilators or windows as soon as it becomes laden with moisture. Sometimes a little additional heat may be desirable to aid in drying the seed. For full directions for the curing and care of seed refer to Farmers' Bulletin 1175, Better Seed Corn.

COMMERCIAL SEED

Commercial seedsmen have given especial attention to the development of improved varieties of sweet corn and to the production of seed therefrom. Many firms make a special effort to maintain high-quality stocks of the important varieties, and these stocks will undoubtedly continue to be the main dependence of a large proportion of growers of canning-crop sweet corn.

¹ Out of print, but may be consulted in libraries.

VARIETIES

A fairly wide range of varieties has been used for canning, since style of preparation and handling has not had much influence on choice of corn. Until the last two decades only white corn was canned; at the present time, however, yellow varieties are increasingly used. The conditions that have determined which varieties should be canned have been climatic and economic.

If a flat price is given to the growers for corn delivered to the cannery, the grower will naturally desire to have the variety that gives the greatest tonnage per acre. The canner will choose the variety with the highest yield of canned corn per ton of raw stock. Therefore, where the climate allows, the variety chosen will be late



FIGURE 3.—Seed sweet corn drying on wire supports under an open shed.

and deep grained, since these varieties are more productive and will give the most cases per ton of ears. These considerations probably account for the use of Stowell Evergreen and Country Gentleman where the growing season is of sufficient length.

In some regions where these varieties are canned the summer temperatures are high and sweet corn passes its prime condition very rapidly. This makes the work of obtaining the finest grade of product more difficult. It is evident, therefore, that the canner who is located as far north as corn can be grown will have a longer period of time when his corn will be in prime condition, and with the same degree of careful attention he will be able to procure a better product than his competitor farther south. He cannot grow the late varieties, however, and must use earlier types of lower production. Crosby corn in the past has furnished most of the product for the northern packers. Since 1915 much more attention has been given to the canning of yellow varieties.

The influence of style of pack on varieties used has not been very great. Originally the grains of corn were cut from the cob by hand and were canned whole with the addition of a liquor containing sugar and salt. When machine cutters were devised the grain was cut across and much of the contents was scraped out, leaving a part of the skin of the grain attached to the cob. This made a more creamy product and did not require the addition of so much liquor to give a desirable consistency. While there has been some whole-grain corn packed at all times, by far the major part of the canned corn until very recently has been of the creamy type often spoken of as "Maine style." However, whole-grain corn is apparently coming into popularity again. Although any variety of corn may be canned in either of these two ways, small grains have been thought desirable for the creamy pack, and the selection of canning corns in recent years has tended to produce narrow-grained sorts.

In the past few years remarkable progress has been made by State and Federal research agencies and by private individuals and firms in the development of new hybrid and top-crossed sweet corns having high quality, improved uniformity, resistance to bacterial wilt (Stewart's disease), and much higher yielding capacity than the ordinary varieties. One of the most important of these, Golden Cross Bantam is briefly described below, along with other important canning sorts.

GOLDEN CROSS BANTAM

Golden Cross Bantam is a new hybrid yellow sweet corn of high quality, that is high yielding and resistant to bacterial wilt (Stewart's disease). It has quickly become a canning variety of major importance.

This hybrid cannot be reproduced from its own seed. It is produced only from crossed seed obtained by controlled cross-pollination of two inbred lines designated as Purdue Bantam and Purdue 51. These inbreds and the first cross were developed by the United States Department of Agriculture and the Purdue University Agricultural Experiment Station.

Golden Cross Bantam is similar to Golden Bantam in color and quality, but the plant is sturdier and plant and ears are larger. It is an early midseason sort, reaching the canning stage 85 to 95 days after planting in Indiana or States of similar latitude.

The stalks average about 6 feet tall but range from 4 to 7½ feet, depending on environment. Under favorable conditions two ears are produced on each stalk.

The ears are tightly covered by rather thin husks. The husked ears are about 8 inches long, nearly cylindrical, and have 10 to 14 straight or slightly winding rows of kernels. The white cobs taper slightly toward their well-rounded tips. At the canning stage the kernels are of medium size, somewhat narrower, and deeper than Golden Bantam kernels. They are light golden yellow and tender, and they harden less rapidly than Golden Bantam. The dry mature kernels are dark orange.

Crossed seed for the growing of this hybrid is now being produced in large quantities by a number of seed firms who make a specialty of sweet-corn seed for canners.

Golden Cross Bantam and its parents are discussed in detail in Circular 268, Golden Cross Bantam Sweet Corn.²

STOWELL EVERGREEN

Stowell Evergreen is a well-known variety, named before 1865. It has a wide range of variation. Its popularity has led to extensive selection, so that it becomes the parent of a number of named strains, such as Early Evergreen, Narrow-Grained Evergreen, White Evergreen, Zigzag Evergreen, and Club Evergreen.

Stowell Evergreen is medium to late in season. The stalk is sturdy, usually standing well, 7 to 8 feet tall. The ears are large, 14-rowed to 20-rowed, with kernels in rows (fig. 4). The grains are white, long, drying into a distinctive flattened shriveled shape, with the top usually bent in drying. The large size of the ear, its deep grain, and its productiveness are all valuable characters for a canning corn. It has the reputation of staying in prime condition longer than most varieties, and careful tests indicate that the claim is justified to some extent, but it is certain that claims for this character have often been exaggerated.

Most strains of Stowell Evergreen produce ears with a large number of rows and narrow grains. These types have been selected by a number of seed growers and experiment-station workers, so that there are several independent narrow-grained selections. These have been in much demand by canners, but some of them have failed to show the vigor and productiveness of the parent variety. It may be that the smaller size of the seed gives a less vigorous start and so handicaps the young plant.

Early Evergreen differs so much in the characters of the grain that it may well be a cross rather than a selection from Stowell Evergreen. The plant is shorter than Stowell and several days earlier, the ears are not so large, and the grains are not so deep and do not become so flat in ripening. It can be grown farther north than Stowell.

The other selections are not so much in favor with canners.

White Evergreen has been selected for a purer white color than the Stowell type.

Zigzag Evergreen is a fairly old selection in which the grains are arranged irregularly on the cob, showing no rows. It has been offered for sale by seedsmen for several years.

Club Zigzag has much the same character of grain as the last but has a larger ear, often flattened on the tip. It has been popular with market gardeners near Cincinnati, Ohio, but is not adapted for canning machinery. It has seldom, if ever, been offered by the seed trade.

COUNTRY GENTLEMAN

Country Gentleman when originally introduced, about 1882, carried the name of Ne Plus Ultra. It is also often called Shoepeg. It is a late variety, with stalks 7 feet high. The ears are often tapering and are 6 to 7 inches long. The grains are arranged so irregularly

² For sale by the Superintendent of Documents, Government Printing Office, Washington, D. C., at 5 cents.

that no rows are apparent from inspection of the husked ear. The grains are long and very slender and they shrivel on drying, similarly to the grains of Stowell Evergreen, rather than wrinkle like Crosby or Golden Bantam (fig. 5).

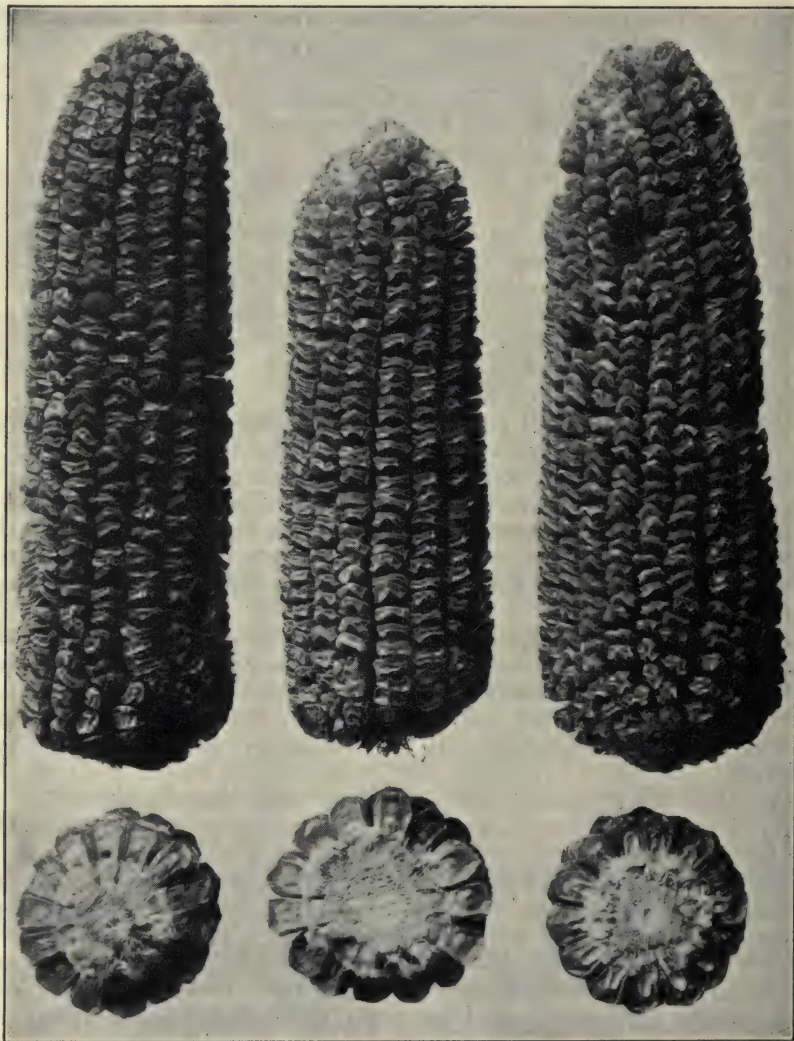


FIGURE 4.—Stowell Evergreen sweet corn. (One-half natural size.)

Country Gentleman has been popular as a canning corn because of its productiveness and its deep kernels, which give a high percentage of cut-off corn.

CROSBY

The Crosby variety was first introduced about 1860. It is an early white corn and has been very popular for canning in Maine and parts of Minnesota. Its fairly robust stalks are 5 to 6 feet high.

The ears are cylindrical, 5 to 6 inches long, with 12 to 16 rows of grains. The grains are closely wrinkled, square, and shallow (fig. 6).

It may be that part of the reputation for the high quality of northern sweet corn is due to the varieties used as well as to the more favorable climate.

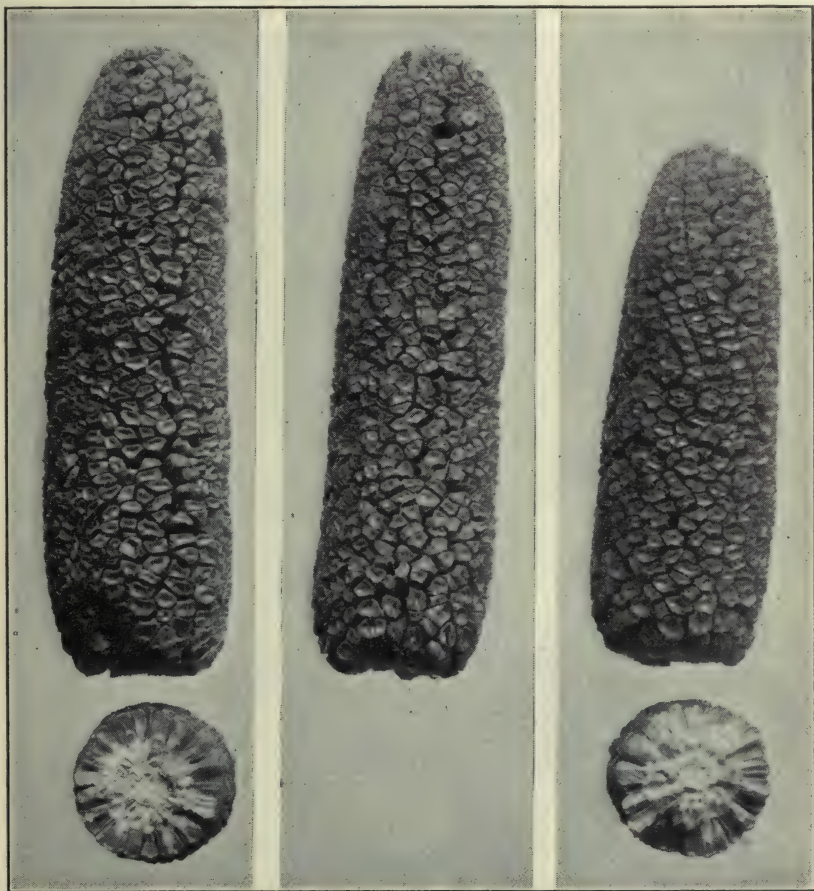


FIGURE 5.—Country Gentleman (Ne Plus Ultra) sweet corn. (One-half natural size.)

GOLDEN BANTAM

The Golden Bantam variety was introduced about 1900. It is somewhat earlier than Crosby and has a stalk not quite so heavy. The ears are cylindrical, 5 to 6 inches long, with eight rows of yellow, broad, shallow, closely wrinkled grains (fig. 7).

This variety first became popular as a home-garden corn. It has since been used extensively as a market-garden corn and in recent years as a canning variety.

Various types have been developed by selection by seedsmen and experiment-station workers. The most pronounced variety has recently been sold as Fourteen-Rowed Bantam, the ear of which is longer and larger but has the same type of grain as the parent sort.

Golden Bantam has been used in intervarietal crosses. Some of these crosses are Golden Bantam $\times$ Stowell Evergreen, Golden Bantam $\times$ Country Gentleman (called Golden Cream), Golden Bantam $\times$ Howling Mob (called Golden Giant), and Golden Bantam $\times$ Crosby. These various crosses and their interest to canners everywhere illustrate the present vogue of yellow sweet corn for all purposes.

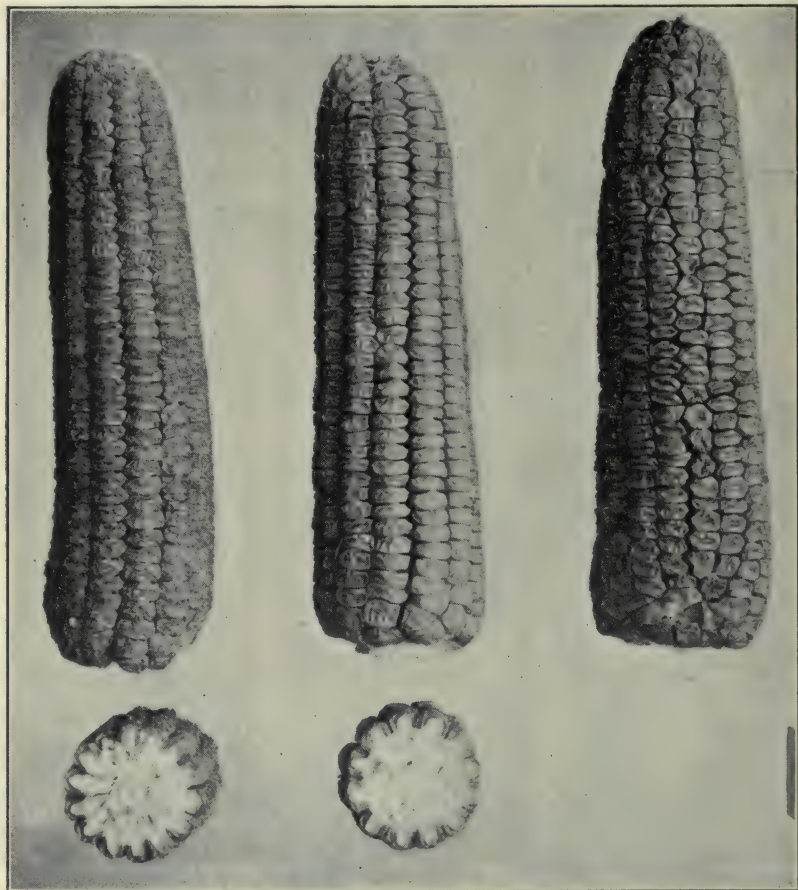


FIGURE 6.—Crosby sweet corn. (One-half natural size.)

PLANTING

GRADING THE SEED

Experimental and practical results have shown it to be desirable to grade sweet-corn seed according to size before planting, and to plant the different grades in separate blocks in the field. The shelled seed is usually passed through a grader which separates it into two sizes, large and small. Many canners who possess pea-cleaning machines have adapted them to the grading of corn, and others have used small seed-corn graders found on the market.

The larger kernels produce a better stand and larger, stronger plants which reach the canning stage two or three days earlier than those from small seed. Planting the two grades in separate blocks in the field gives more uniform stands, and when this method is followed the uniformity of reaching the canning stage within each block is definitely superior to results obtained with seed of mixed sizes. The same planter plates should be used for both sizes of seed even though a larger number of small kernels will be planted. The probability of a poorer stand from the small kernels makes it advisable to plant a larger number. The weight of seed planted per acre will not be materially different.



FIGURE 7.—Golden Bantam sweet corn. (One-half natural size.)

TIME OF PLANTING

The planting of sweet corn is ordinarily deferred until warm, settled weather is assured, because of the inability of the seed to germinate properly when placed too early in cold, wet soil. However, in the Prairie States and in those around the Great Lakes it is a common practice on sufficiently dry soils to risk an early planting to insure a crop before the early fall frosts. The best corn is usually the result of moderately early planting combined with good soil preparation. The exact date of planting will vary, and it is normally determined in conference with the factory operator, who seeks a long, uniform maturing of the crop in order to maintain a satisfactory canning schedule.

PLANTING SYSTEMS

Systems followed in the planting of sweet corn for a given locality are usually identical with those of field corn. Drilling the seed so that the plants will stand singly in rows rather than in hills is an accepted practice in some sections. This method of planting may be especially desirable on hillsides or on rocky, stumpy ground, following either the contour or a straight line. When a checkrow planter is used, kernels are dropped in a hill, the number per hill and the interval between hills being regulated by the dropping device of the planter. The hills are so alined that straight rows are formed at right angles to the direction of the planter rows. Since cultivation can be alternated in direction in a "checked" field, the grower can keep the entire soil surface free from weeds and in good condition with the minimum amount of hand-hoeing. This system is best adapted to nearly level fields that are comparatively free from obstructions.

PLANTING DEPTHS AND DISTANCES

The depth of seeding will be governed by the nature and moisture content of the soil. In heavy clay soils or those especially retentive of moisture, a depth of 1 to 1½ inches seems suitable in most localities. In loams or sandy loams, 1½ to 2 inches is recommended, but when the soils are very light, warm, and dry, or when the area is subject to drought, the depth should be increased. However, if corn is planted too deep, the young seedling will be exhausted before the leaves can start vigorous growth above ground.

The rate of seeding will be influenced by the planting distance, by the locality, by the variety, and by the richness of the land, varying from about 10 to 15 pounds of seed per acre. More kernels can be planted per hill on strong land than on thin land, but in most important sweet-corn growing regions three to four stalks per hill have given the best returns at the usual spacing. It may be advisable to drop more kernels than the actual number of stalks desired, to compensate for losses from insects and other causes. Too many stalks per hill will reduce the size and the total yield of ears.

Sweet corn does not grow as tall as field corn, and it is sometimes grown closer together than the field types. The distance between rows and between stalks and hills affects to some degree the yield per acre. Plants spaced too close together give a decreased yield of ears and an increased weight of stover, while if the planting is too sparse both will be reduced. Short-growing and early varieties may be planted 30 to 36 inches apart, and the medium or large-growing varieties, 36 to 42 inches. If the seed is drilled, single stalks should stand 12 to 15 inches apart in the row, and if in hills they should be from 28 to 36 inches apart. Rich soils having ample moisture at the time of the formation of the ears will also bear thicker planting. The proper planting distance is another question that must be answered differently in different localities.

Some canning concerns insist that the grower separate the plantings of white and yellow varieties of sweet corn. Since this crop is wind-pollinated, the white ears may be exposed to cross-pollination with a yellow variety. The kernel color of a yellow-pollen parent becomes evident the same season that the crossing occurs, so that if pollen from a yellow variety reaches the silks of a white variety the

white ears may show some yellow kernels at harvest time. If a yellow variety is exposed to the pollen of a white variety, no effect will be seen in the resulting ears. However, if these ears are used for seed, white-kerneled plants may appear among the yellow planting. When the corn is to be used in the factory the white varieties should be planted some distance away from and to the windward of the yellow strains, because the canner will reject all white ears showing yellow kernels. Whenever sweet corn is grown for seed the two types should be widely separated.

REPLANTING

It is a waste of land and of labor to carry a poor stand through to the harvesting period. Whether to replant or not depends upon whether there will be sufficient time after replanting for the crop to reach proper maturity before frost. As a rule, it does not pay to replant an occasional hill, because of the retarded growth and poor yield resulting from the competition of the adjacent plants. If the stand is so poor that replanting is advisable, the soil should be disked and the whole field replanted. Interplanting between the rows without destroying the old crop results in a weedy replanted crop and is of doubtful value.

CULTIVATION AND CARE

The advantages of early planting may be lost unless it is promptly followed by cultivation, for the growth of the crop may be seriously harmed if a hard soil crust interferes with the emergence of the seedlings, or if weed growth is allowed to rob the crop of moisture and nutrients. Sweet corn does not differ greatly from field corn in its cultural requirements.

Soon after planting, before the corn is up, all weeds that have started should be destroyed by shallow harrowing or by the use of a rotary hoe or other suitable shallow tillage implement. This preliminary cultivating or weeding also breaks up a hard crust that might interfere with the young seedlings. It is a simple, rapid, effective, and inexpensive method of holding weeds in check until the corn is 5 or 6 inches high. Thorough weed control up to this time, by such a method, greatly reduces the cost and increases the efficiency of later cultivation.

Shallow cultivation, as a rule, has proved to be more satisfactory than deep cultivation. Deep culture tends to break the roots of the corn plant, thereby interrupting the absorption of water and plant food. While the plant may produce new roots, this can be done only at the expense of ear and fodder production. Deep cultivation should be used only during the early stages of the growth of the crop and after excessive rains have packed the soil. A shallow soil mulch of from 1 to 2 inches in depth should destroy all weeds without injuring the roots of the crop.

The number of cultivations necessary will depend upon local conditions. The cultivator should be used following a rain as soon as the soil is dry enough to permit stirring without injury to its texture. The soil mulch should be promptly restored to prevent the baking of the surface soil and to destroy weed seedlings before they have become firmly established. If necessary in order to control weeds,

shallow tillage should be continued through the tasseling period. It is sometimes profitable to remove occasional weeds by hand-hoeing even as late as the silking time of the corn. Often the grower will sow a catch crop for late pasturage, covers crops, or winter wheat or rye, to be cultivated into the soil with the last cultivation.

A choice from among the many types of cultivators that are available should depend upon local conditions. The use and advantages of several good types of cultivators are explained in Farmers' Bulletin 1714, Corn Culture.

Removing the suckers from the base of sweet-corn plants is an old practice based on the belief that their removal increases the yield and size of the ear and promotes earliness. Recent experimental work shows that plants suckered early produced no greater number of ears and no higher yield by weight than those not suckered. In fact, they produced very slightly less. Poor returns were obtained when suckering was delayed until the tassels were forming. Under normal conditions, suckering is a practice that cannot be recommended in the growing of corn for canning, because of the labor and expense involved, and because no definite increases in yield result, while definite decreases may result. For those who depend upon stover for livestock it will result in the loss of some feeding material.

HARVESTING

The date of harvesting varies with the locality, the variety grown, the time of planting, and also varies in a single locality from season to season. The kernels should be plump and full of milk and this stage normally coincides with the time when the silks begin to turn dark brown. Some experience is needed in picking the crop, the harvester being guided by the appearance of the silks and by feeling the ears to ascertain the plumpness of the kernels. The ears are snapped in the husk, leaving a short stalk at the base of the ear. Some factories require that the ears be cut with a short butt in order to decrease the weight of waste, part of which might consist of long shanks.

High quality in sweet corn is closely associated with the sugar content of the kernels. During the ripening process the sugar changes rapidly to starch, the kernels passing successively through the premilk, milk, early dough, and dough stages. The corn should be harvested in the milk stage in order to obtain a product of the best flavor and most desirable consistency. If harvested too soon, the yield in tons of ear corn per acre and in cases of canned corn per ton will be low and the canned product will lack body. If harvested late, the product will be lacking in flavor, will be starchy, and will contain tough seed coats.

Sweet corn passes through the milk stage in a very short time. Temperature has been shown to be the most important controlling factor in the rate of ripening. In the most southerly corn-canning regions, or during a period of warm weather farther north, the ears may remain in prime canning condition no longer than 2 days. Under such conditions harvesting must be started promptly at the proper time and completed as rapidly as the factory can handle the corn. Farther north where the summers are cooler, or southward

when the corn is planted to be canned late in the fall, it may remain in good canning condition for as long as 5 or 6 days. Under high temperatures, when ripening is very rapid, the usual test of quality, which consists in squeezing out and examining the contents of the kernel, is a less dependable index than under cool conditions.

Bearing in mind the rapid rate at which sweet corn passes through the proper stage for canning, one can readily understand why uniformly maturing stands are important. Ungraded seed, which may give as much as 2 days' variation in time of reaching the milk stage, obviously would not yield a high-quality, uniform product if the crop were harvested all at one time. In order to obtain good quality it would be necessary to harvest the field repeatedly, which is expensive, and even then the product would be lacking in uniformity.

The ripening process in green sweet corn continues after it is harvested, and the quality deteriorates rapidly. High temperature hastens this condition very markedly. Piles of corn at the factory or even loads of corn on wagons soon begin to heat, and a great loss in flavor results.

Sweet corn is usually harvested in the morning so that it may be handled at the factory without delay. Harvesting late in the day often gives rise to congestion at the factory, with the result that the corn deteriorates in quality before it can be placed in the cans. Most sweet-corn fields are harvested but once, an exception being made in years of low yields or in the case of unevenly maturing plantings, when the fields may be gone over two or three times. The nubbins and the green ears are left on the stalk.

YIELDS

The yield of sweet corn depends upon the variety and the conditions under which it is grown. This latter factor includes the soil, its preparation and fertilization, the rate of seeding, and the distance of planting, the efficiency of cultivation, weather conditions, and the effects of weeds, disease, and insect pests.

Although the yield of sweet corn grown for a canning crop in the United States during the period from 1926 to 1929 averaged 2.07 tons per acre, yields may range from one-half ton to 8 tons per acre. A yield of 4 tons is not unusual.

FACTORY WASTES

Canning-factory wastes, including the husks, shanks, silks, and cobs of sweet corn, were formerly considered worthless and were left in piles to decompose or were hauled away to a dumping ground at considerable expense. On the basis that from 600 to 900 pounds of canned corn is obtained from 1 ton of sweet corn as delivered, the canning concern must consider the disposal of wastes amounting to from 55 to 70 percent of the original material. These wastes are now considered a valuable byproduct, but in some regions this material is being neglected because its feeding or manurial value is not fully appreciated.

SWEET-CORN WASTE AS SILAGE

Many of the larger factories are equipped with a silo or a battery of silos in which to conserve the sweet-corn wastes (fig. 8). Some-

times only the husks are made into silage, and since they may ferment too rapidly the action is often retarded by mixing some drier material, such as oat straw or dry fodder from the field, with the greener material. The cobs have sometimes proved unsatisfactory when used whole. A part of the failure in making sweet-corn silage is probably due to the fact that whole cobs from the factory do not pack tightly into the silo. The presence of air in unpacked silage



FIGURE 8.—Silos used for preserving the husks and other waste from sweet corn.

prevents the proper preservation of the material. Some operators run the cobs through silage cutters or shredders so that the mass will pack to better advantage. Silos for the individual grower are common in dairy and livestock-feeding sections, and frequently a part of these factory wastes is obtained by agreement and ensiled on the farm.

Some canning firms pile their corn wastes in large stacks, covering the accumulation of pea vines and other material obtained earlier in the season. These stacks may be of any size or shape and are frequently as large as 80 feet long, 20 feet wide, and as high as it is convenient to make them. Care is taken in forming these stacks by maintaining a steep pitch to the sides and thoroughly trampling the mass to exclude the air and to insure proper fermentation. A ditch is usually made around the edges of the refuse piles to carry away the liquid seepage that oozes from them. This liquid should not be placed on farming land, for it has an injurious effect on the crops because of its souring, fermentative action.

Most contracts contain a statement providing that the corn husks and cobs are to belong to the factory. The canner may allot a reasonable quantity for immediate feeding during the canning season or

may reserve the fresh and ensiled material for his own feeding operations, or he may distribute the cobs, retaining only the husks. Often the factory sells the silage to the producers and, in case of surplus, to other feeders of livestock.

FACTORY WASTES AS MANURE

The factory wastes have some fertilizing value as manure. Husks, especially the completely decomposed outer layers of the stack, have been used as orchard mulch. Although the practice is not always advisable, cobs have been spread on heavy clay spots in fields in layers about 6 inches deep. During the first year after plowing under the results proved discouraging because of the slowness of decomposition, but after a second season the land became friable and mellow, bringing the soil nearer to desirable cultural conditions. The husks decompose more rapidly than the cobs, but are seldom used because of their greater value as silage. It will perhaps be better if this roughage is first fed to stock, as only a portion of the fertilizing constituents need be lost in animal feeding. Then if the manure is given protection from weathering and losses from seepage, a double value will be obtained, first from the palatable fodder and later in the use of the manure.

DISEASES³

Root rots cause great losses in sweet corn, especially in the field-corn regions. Infection of a crop may occur from diseased seed or from soil that contains the organisms. In either case the corn crop gives reduced yields, irregular growth and maturity, barren stalks or stalks bearing nubbin ears, and plants that die prematurely. Experimental work shows that the infection of seed may be considerable and that it pays to test all seed stock and to discard that seriously infected. The grower should select disease-free ears. If there is any question as to freedom from disease, the seed should be treated with one of the organic mercury dusts recommended for seed treatment. The rotation of crops and the maintenance of a highly fertile condition of the soil will keep down to some extent the amount of damage if the soil becomes infested.

Smut is a widely distributed disease, attacking the stalks, ears, and tassels of the sweet-corn plant. The organism produces irregular galls or outgrowths, covered at first with a white membrane, but later breaking open and scattering masses of spores. The smut fungus will infect at any actively growing point or fresh wound on the plant at any period during the growth of the crop. In valuable plots the amount of damage can be reduced by cutting away and burning all smutted parts before the smut galls are mature. Treatment of the seed to prevent smut is of no avail. Rotation of crops should be practiced, and land should not be top-dressed with manure or refuse matter produced from the feeding of smut-infected corn stover to livestock. The ensiling of corn is said to destroy the smut spores.

Ear rots are caused by several fungi and produce imperfectly developed ears which are soft and often covered with a mold. The ear rots are of importance chiefly where sweet corn is grown for seed. The trouble is more serious in moist, warm weather. Control meas-

³ Prepared by A. G. Johnson, principal pathologist, and Charlotte Elliott, associate pathologist, Division of Cereal Crops and Diseases, Bureau of Plant Industry.

ures include the practice of a rotation, clean cultivation, and the use of disease-free seed or seed of disease-resistant strains.

Bacterial wilt or Stewart's disease of sweet corn occurs every year in the Middle Atlantic States, where only resistant varieties can be grown to advantage. In most years the disease is unimportant in other sweet-corn-growing sections. Following a series of mild winters the disease occasionally causes serious losses throughout the Corn Belt and may spread into the Northern States and Canada. The bacteria live over winter in one of the corn flea beetles and are carried to the young corn plants upon which the beetles feed. Throughout the season the beetles spread the disease by carrying the bacteria from diseased to healthy plants. Long, light-yellow streaks develop in the leaves, bacteria fill the vessels or water-conducting fibers of the stalk and ooze out as yellow beads from the cut ends. Plants may wilt and die or remain stunted, develop premature tassels, and bear nubbins or no ears at all. Golden Bantam and other early varieties are most susceptible. Late-maturing varieties are resistant. Resistant strains of Golden Bantam and other early varieties have been developed recently in cooperative studies carried on by the Department of Agriculture and the experiment stations, and by the stations and other agencies which offer an effective means of control.

For detailed information concerning these or other disease troubles, communicate with the State agricultural experiment station or with the Bureau of Plant Industry, United States Department of Agriculture.

INSECTS⁴

Many species of insects are known to be injurious to Indian corn, and practically all of these attack sweet corn. Some of these cause damage such as to reduce materially the yield and quality of the product. Among the more important insect pests of this group are the following: Corn earworm, European corn borer, common corn-stalk borers, webworms, armyworm, army cutworm, fall armyworm, chinch bug, green bug, corn-leaf aphid, corn-root aphid, white grubs, leafhoppers, grasshoppers, wireworms, seed-corn maggot, and southern corn-root worms.

The control of these pests in sweet corn for the most part is similar to the control for such insects in field corn. However, the control measures differ somewhat because of the variation in cultural practices and more particularly in the value of the crop per acre. Information is usually available on the biology and control of most of these insects, and although the damage caused by various species may look the same, the control measures are usually different for the various species in the same locality and even the same species in different parts of the country.

When injury is observed and information is desired, specimens of the insect causing the damage and a sample of the injured plant should be sent either to the State agricultural experiment station or to the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture.

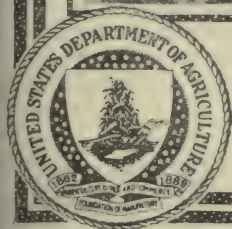
⁴ Prepared by W. H. Larimer, principal entomologist, Bureau of Entomology and Plant Quarantine.

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U. S. DEPARTMENT OF
AGRICULTURE

FARMERS' BULLETIN No. 1635

SURFACE
IRRIGATION
IN THE
EASTERN
STATES



IN THE EASTERN PART of the United States irrigating to increase production and to protect valuable crops from drought has been done chiefly by two methods—spray irrigation and subirrigation. Both systems are expensive, and subirrigation is not satisfactory except under special soil conditions. Little attention has been given in the East to the irrigation of the less valuable crops or the watering of the more valuable crops by a cheaper method.

This bulletin explains surface irrigation, which is simpler and less expensive than either spray or subirrigation. The information should be helpful to eastern farmers whose crops have suffered from drought but who from their knowledge of the high cost of the spray method and of the limited applicability of subirrigation have been discouraged from attempting irrigation of any type.

This bulletin supersedes Farmers' Bulletin 899, Surface Irrigation for Eastern Farms.

SURFACE IRRIGATION IN THE EASTERN STATES

By F. E. STAEBNER, Associate Drainage Engineer, Division of Agricultural Engineering, Bureau of Public Roads

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INTRODUCTION

IN NEARLY ALL parts of the Eastern States the yearly rainfall is more than enough to grow good crops if rains come at the right times, but nearly every year some crops suffer from lack of moisture. Although this is well known, the losses from drought are not regular enough nor sufficiently widespread to force general practice of irrigation to supplement rainfall.

It is not to be expected that irrigation would be worth while for all crops nor in all parts of the East. But in those sections where dry periods occur often, a farmer should be able to increase his average production with the aid of irrigation. However, to justify the cost, the crops raised must be worth more than those raised without irrigation. This increased value must, on the average, be at least large enough to cover taxes, interest on the original cost, and the depreciation, maintenance, and operation charges on the necessary equipment. This means more intensive farming, sure markets, and the ability to grow and handle a greater quantity or a higher grade of crop, or both.

In many cases the probable increase in crop value is not enough to pay for putting in a spray-irrigation plant. In such cases a cheaper method of applying water may be profitable, as for instance where high-priced crops such as green beans, eggplant, etc., are grown by field-crop methods, or where less valuable crops are grown such as Lima beans and potatoes, which respond well to irrigation. Under such circumstances it may be well to consider surface irrigation.

IRRIGATION METHODS

Three methods of irrigation are employed in the Eastern States. These are known as subirrigation, spray irrigation, and surface irrigation. The latter method, however, has been employed far less than its possibilities warrant.

Subirrigation consists in watering the soil and the plant roots from below rather than from the ground surface or above. The water is delivered to the soil either from open ditches or from the open joints of tile laid underground. From these ditches or tile lines the water seeps into the soil of the field to be watered. Subirrigation requires an open surface soil, and a tight subsoil that will hold the water within the root zone of the plants. For successful subirrigation the surface of the ground must be level or at least have a slight, uniform slope. More water is required than for the other methods; therefore it seldom pays to pump water for subirrigation. Where conditions are favorable it is a most excellent method, but unfortunately these conditions are to be found in but few places in the eastern part of the United States.

In spray or overhead irrigation,¹ water is applied to crops in a fine spray. The method can be used on either level or hilly land and on any type of soil. The water is supplied under pressure, which is provided by an individual pumping plant unless city mains are tapped. The distribution system of the most common type of spray plant costs from \$175 to \$225 an acre irrigated. The main pipe line running from the water source to the field, and the pumping plant or connection to a supply main, involve additional expense. The type of system just referred to, for 5 and 10 acre units where pumping is from wells or streams to adjacent lands, costs for construction from \$250 to \$375 an acre, and sometimes more. Thus the crop which will justify irrigation by this method must be such as will by irrigation be increased in selling value at least \$50 or \$60 per acre per year, which will be required to pay taxes, interest at 6 per cent on the cost of pumping equipment and distribution system, 7 per cent for depreciation of plant, and the upkeep and operation expenses.

SITES ADAPTED TO SURFACE IRRIGATION

Surface methods of irrigation are of four general types—furrow, flooding, check, and border—all of which are used extensively in the arid sections of the Western States.² Except in the irrigation of rice and cranberries, only the furrow and flooding methods are used in the East. The furrow method is used for the irrigation of cultivated row crops and orchards. The citrus groves of Florida are irrigated by this method. Many farms use a combination of the spray and furrow methods. In such cases spray irrigation is applied to seed beds, quick-growing market-garden crops, berries, and crops grown on rolling lands which are not well suited to surface irrigation; while the furrow method is used for crops on even slopes which are cultivated with horse or tractor-drawn implements.

The flooding method is seldom used since small-grain crops and meadows, to which this method is best adapted, are not ordinarily irrigated. This method requires a nearly level ground surface, and eastern soils seldom are deep enough to permit of much grading. However, if fields can be leveled properly and water can be applied cheaply enough, there is no reason why the flooding method should not be used.

¹ Farmers' Bulletin 1529, *Spray Irrigation in the Eastern States*, describes in detail the construction of small or moderate-sized systems.

² Farmers' Bulletin 864, *Practical Information for Beginners in Irrigation*.

The uniformity of water distribution possible with the spray system can not be had with the surface methods, and the labor required in watering a field by the latter methods usually is much more than that required by the former.

THE WATER SUPPLY

In the East it usually is not practicable to divert water directly to the land from a stream, as is done frequently in the West, because such a diversion must be made at a point far enough upstream to permit the water to flow down the ditch to the land to be irrigated. Often this would require a ditch of considerable length, and where the land which must be crossed by the ditch is of much value or belongs to other persons the obstacles in the way of constructing a gravity supply system are serious. A pumping plant, therefore, usually is necessary for an irrigation system in the East, whether the source of supply be a well, a stream, or a lake.

Occasionally an irrigator has a choice between two possible sources of water. More frequently but one source is available, and many times investigation shows that even that one is not adequate for the plan he has in mind. In that case the entire irrigation project must be given up or the plan changed. Whether it is wise to attempt to use any given water supply depends upon a group of interrelated factors, but final decision must be controlled by the profits reasonably to be expected to result from irrigation. These expected profits will depend, (1) upon the crop to be grown—how valuable it is and how readily it responds to irrigation—and (2) upon the cost of irrigation.

The location of the water supply has an important bearing on the cost of irrigating. A long pipe line always adds materially to the expense; therefore a water-supply that is very near the field to be irrigated is generally to be preferred and is a necessity in the case of crops where the increased yield due to irrigation would be small. The height to which the water must be lifted is also important although in any going enterprise the actual cost of pumping generally is overshadowed by other costs. This is particularly true if a tractor, also used for other farm purposes, is used to furnish power for pumping, as the irrigation plant is then only chargeable for a part of the interest, taxes, and depreciation. For a water supply to be valuable in such case, it is of course necessary that the lift be not beyond the power of the tractor to raise the necessary water.

The expense of making the water supply available to the land must also be considered. The cost of a well or of building an expensive dam in a stream adds to the proper annual charges against irrigation. If a storage reservoir is needed to make a small water supply useful, its cost should also be considered.

QUANTITY OF WATER NEEDED

In the eastern or humid sections irrigation is undertaken mainly as insurance against loss from drought. Therefore it is necessary that the plants receive at each irrigation enough water to keep them in good condition for several days. About 1 inch in depth over the surface of the irrigated field, if uniformly distributed, usually meets

this need. This quantity of water is known as 1 acre-inch per acre and is equal to 27,152 gallons. Usually some losses occur in handling irrigation water, and uniform distribution is seldom possible. For this reason, more water than the quantity mentioned above must be available, and for each average irrigation about 2 acre-inches per acre will be required when a heavy soil, with considerable clay, is being irrigated, and 3 or 4 acre-inches, or even more, when a sandy soil is irrigated. In general, then, the quantity needed is from 50,000 to 100,000 gallons per acre for each irrigation.

The quantity of water required for each irrigation, once established, it becomes important to know how often these waterings must be made. This frequency varies with the locality and the season of the year in which drought occurs as well as with the crop; but for any given crop, locality, and season the greatest need for water usually comes during the hot days of summer. The number of days which may properly be allowed to pass between irrigations during the hot part of summer, in case plentiful rains do not occur, has been shown by experience to be about as follows: For green beans, Lima beans, cabbage, cauliflower, sweet corn, eggplant, mangels, peas, spinach, and home garden, 7 days; for alfalfa, potatoes, and tomatoes, 10 days; for grapefruit and oranges, 15 days. Some crops do not need irrigation at regular intervals but do require that plenty of water be supplied at certain critical periods. The following suggestions are made with reference to some of these crops: Crimson clover, one irrigation at seeding in July or August and one irrigation in the spring if very dry; field corn, one irrigation at ear-setting stage if dry; sweetpotatoes, one irrigation when vines start and one or two about 2 to 3 weeks before harvesting; strawberries, once every 3 days at time of fruiting.

The above figures indicate the periods within which the tract should be watered if the whole irrigated area is devoted to one crop. They must not be taken to mean that the shallow-rooted, delicate crops themselves require so much more water than do the deeper rooted and hardier crops but simply that the waste of water due to seepage below the root zone, and to evaporation, will be less in the case of the deep-rooted crops.

It is true that outfits that are unable to cover their entire areas within the periods given above are proving well worth while to their owners. In using equipment with such reduced capacity on a variety of crops it usually is best to apply most of the water to the more delicate or more valuable crops. It is always desirable to water thoroughly whatever part of the area is watered at all, even though the entire area may not be covered.

The number of acres to be irrigated, then, will determine the total quantity of water needed, and the time the irrigator allows for putting this water on the land will determine the quantity of water needed in a given period of time. For instance, if one wishes to irrigate 1 acre of stiff soil in one day, and to irrigate 12 hours a day, he will need about 50,000 gallons, or about 4,000 gallons per hour. If, however, he wishes to water only one-fifth of an acre a day he will need only 800 gallons per hour, or about $13\frac{1}{2}$ gallons per minute. If water is scarce it may be necessary to apply water slowly and to irrigate for 10 days or two weeks. Thus, to put 50,000 gallons

on 1 acre in 14 days, irrigating 12 hours a day, one would need $50,000 \div 14 = 3,572$ gallons per day, or about 5 gallons per minute. If the soil is very sandy and the land is flat, at least twice this amount will be needed. However, it is unusual to attempt surface irrigation where only 5 gallons per minute is available, unless the water can be stored between irrigations.

For a larger piece of land the quantity of water needed can be determined in the same way. For instance, if 10 acres of stiff soil is to be irrigated, it is only necessary to multiply by 10 the figures for 1 acre given above. Thus, 50 gallons per minute will be needed for 14 days of 12 hours each, but if the soil is sandy 100 gallons per minute or more will be required for the same length of time. Often it is necessary to figure on irrigating 24 hours a day as a means of using a limited water supply or of reducing the cost of pumps and piping. In such cases only about one-half of the quantity per minute required for 12-hour irrigation would be needed.

Where the water is taken from streams and can be made to flow to the land by gravity, the quantity used is not so important, and often it is desirable to use water more rapidly and to irrigate for shorter periods.

SURFACE WATER SUPPLIES

Lakes, ponds, and streams are common sources of irrigation water. One of the problems is to get the water from the source to the field to be irrigated.

In the East, it is not often that a surface-water supply can be found which is so located that it can economically be brought to the field by gravity. However, where this can be done the expense of irrigation should be small unless a costly dam in the stream or a long pipe line is required, or, in the case of a ditch, unless very rocky or high-priced land must be crossed. If it is necessary to go far upstream in order to get water at a level high enough so that it will flow to the field to be irrigated it may be cheaper to put in a pumping outfit on the bank of the stream close to the field and pump the water to the necessary level. Where the land slopes toward the stream, a long pipe line or a flume supported by trestles may be necessary. The pump should be as near the water as possible and so placed along the bank that the highest part of the land to be irrigated can be reached with the shortest possible length of discharge pipe.

If water for irrigation is taken from a lake, large pond, or large stream there is little danger of a shortage; but if the water is taken from a small stream this may not be the case. It may then be desirable to measure the flow so as to make sure that sufficient water can be obtained. Often this may be conveniently done by the use of a weir. Directions for placing a weir and making measurements will be found in Farmers' Bulletin 813, Construction and Use of Farm Weirs. Such measurements should be made in a dry period, if possible. If it is not possible to make the measurement during the time of the smallest flow, a measurement nevertheless should be made and the dry-weather flow estimated from that figure, bearing in mind that even then the low-water flow is very likely to be overestimated. Irrigation will be needed most in the driest time, and there is little to be gained by installing an expensive irrigating outfit if water is

to be lacking at that time. It must be remembered that it is the least or dry-weather flow of the stream that limits the total area that can be watered.

WELLS

Water for irrigation often is taken from wells, of which there are several kinds. Dug or open wells are used in some sections, but usually the quantity of water that can be obtained from them is too small. Being shallow, they often are dry or nearly so when water is needed most.

Drilled or bored wells frequently furnish large quantities of water. Some wells of this type flow and provide enough water to irrigate several hundred acres. Most of them, however, do not flow, although many such wells will yield plenty of water when pumped.

If the water-level in such a free-yielding well stands within suction lift of the ground surface, pumping is relatively inexpensive. In such a case the water level will not lower much due to pumping, and the machinery can be installed on the ground surface. If the distance between the operating water level and the ground surface is only a little more than the permissible suction lift, the pump may be brought within suction lift by lowering it into a suitable pit. If, however, the water level during pumping is much below practical suction lift when measured from the ground surface, a deep-well pump, which is relatively expensive, will be needed.

Before a new well is accepted from the contractor, it should be tested by pumping to full capacity for 40 to 50 hours without stopping. It is the duty of the well driller to make such a test. While the test is being made the quantity of water pumped and the draw down—that is, the lowering of the water surface due to pumping—should be measured. The quantity pumped may be measured with a weir box placed near where the water is discharged. In determining the draw down the first thing is to measure the distance that the water level stands below the ground surface when the well has not been pumped for several hours. The water level in the well should then be determined at frequent intervals while the test is being made. The water levels before and during pumping may be quite different, as a considerable draw down is to be expected while the pump is running. The draw down is the difference between the natural water level before the test was made and the lowest level found while pumping. The amount of the draw down should be known as it may have an important bearing on the type of pump to purchase and on the way the pump is placed.

The water level in the well before the test is begun may usually be found by means of a float suspended on a string. The water level in the well during the test will often have to be measured by means of a vacuum gauge. If a horizontal centrifugal pump is used for the test this may be done by connecting the vacuum gauge to the suction pipe near the pump intake. The reading of the gauge usually will be stated as so many inches of mercury. To get it into the more convenient unit of feet-of-water, multiply by 1.14. If the gauge has been placed with only a short connection so that it is close to and level with the center of the horizontal part of the pump intake, the figure so obtained is the number of feet between the center of

the gauge and the water level in the well during pumping. This number of feet will then have to be increased or decreased by the distance in feet between the center of the gauge and the ground surface (according as the gauge is below or above the ground surface) to get the distance from the ground level to the operating water level. For conditions where the above method can not readily be used, the reader is referred to Farmers' Bulletin 1404, *Pumping from Wells for Irrigation*.

Driven wells also are used in irrigation. They provide a cheap water supply where the distance the pump must raise the water is less than 25 feet, and the quantity of water needed is not too great. One 2-inch well will usually yield from 10 to 40 gallons per minute if the point is driven into good water-bearing sand or gravel. A

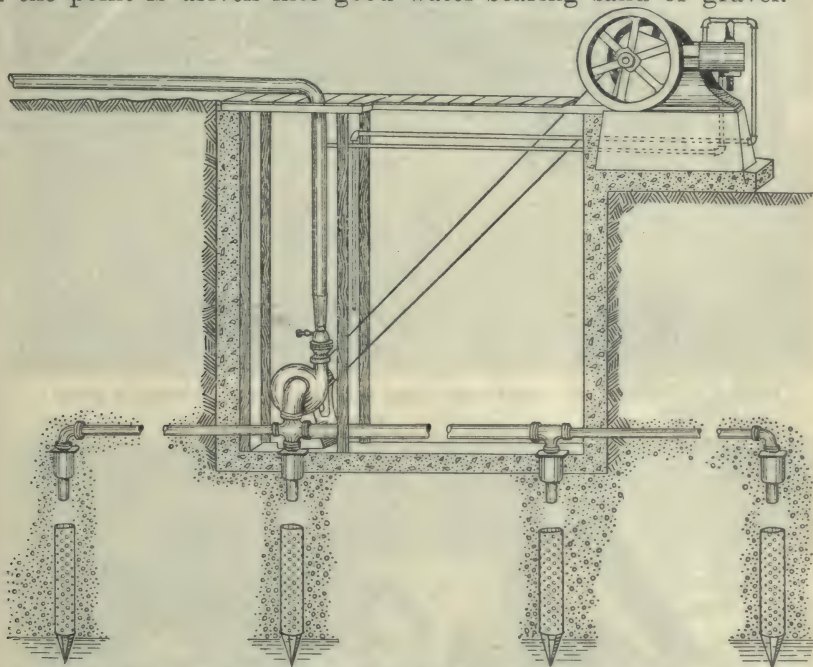


FIGURE 1.—Horizontal centrifugal pump set in concrete pit, to pump from several connected wells. The pit is required because the suction lift from the ground surface is too great

number of points may be driven from 10 to 20 feet apart and connected to one central pump. If the water level is slightly more than 15 feet below the ground surface, the same method often can be followed by digging trenches, laying the connecting pipes in them, and setting the pump in a central pit. The pit and connecting trenches (fig. 1) must be deep enough to bring the water level well within suction lift when the pump is running.

THE PUMPING PLANT

The pumping plant consists of the pump and engine or motor which drives it. For such irregular service as is required for most eastern irrigation plants the best pumping outfit is one that is rugged

and durable, and that will do its work under all conditions with very little attention. Where there is danger of floods, as on a river bank,



FIGURE 2.—Tractor and centrifugal pump delivering water to wooden flume



FIGURE 3.—Tractor and centrifugal pump delivering water to open ditch

it is best to place pump and engine on skids or wheels so that they can be moved quickly and easily. Tractors are well suited to furnishing power in such cases. (Figs. 2 and 3.) Some irrigators,

however, prefer to install centrifugal pumps permanently even under such conditions and let the high waters cover them. The pump shown in Figure 2 was so installed and has been flooded several times. Plunger pumps never should be so placed as to be subject to flooding, particularly if the water is muddy.

THE PUMP

Where surface water is used a centrifugal pump usually is the cheapest and most suitable for irrigation in the East. In this form of pump the rotating shaft carries a system of curved blades known as the impeller. The impeller is inclosed in a water-tight shell or chamber of cast iron. Rapid rotation of the impeller sets up sufficient motion or velocity in the water to drive it through the discharge pipe. The advantages of the centrifugal pump are low cost, simple design, light weight, lack of valves that wear out quickly, ease of operation and repair, and high efficiency in raising large quantities of water through moderate and fairly high lifts.

Centrifugal pumps are made in two general types, the horizontal type (having a horizontal shaft) and the vertical type (having a vertical shaft). Each of these types is made in both the open-impeller and the closed-impeller forms. The difference in these types is clearly shown in Figure 4.

A centrifugal pump with one impeller is known as a single-stage pump. One with two impellers is called a 2-stage pump. Centrifugal pumps are made in several stages. The number of stages required depends upon the height to which the water must be lifted. The ordinary single-stage pump with the open impeller is made to raise water through a total lift of about 40 feet, and this can be done at a moderate speed. By adding more stages the height can be increased, the speed remaining the same, but the cost of these pumps rises rapidly with the number of stages. Single-stage pumps built for high lifts and high speeds may be had, but they cost more than the low-lift and slow-speed pumps and must have more careful attention.

The single-stage horizontal (figs. 1, 2, and 7) type of centrifugal pump is the one most commonly used for irrigation, it being especially suitable for pumping quantities of water above 250 gallons per minute, from streams or from wells where the suction lift is not too great. This pump is made both as a cheap and as a high-grade pump. The cheaper open-impeller pump can be expected to operate satisfactorily where the suction lift is not over 4 feet. It may work well at somewhat higher lifts, but the chances of satisfactory operation decrease as the lift increases above 4 feet. The practical suction lift for the high-grade inclosed-impeller pump is about 15 feet. If the water in the well is at a depth somewhat more than the suction lift the pump can usually be set in a pit and belt-connected to an engine or motor at the ground surface. As a rule a pump can not be operated satisfactorily in a pit more than 15 feet deep.

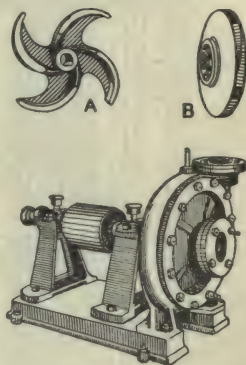


FIGURE 4.—A centrifugal pump showing both open type (A) and closed type (B) of impeller

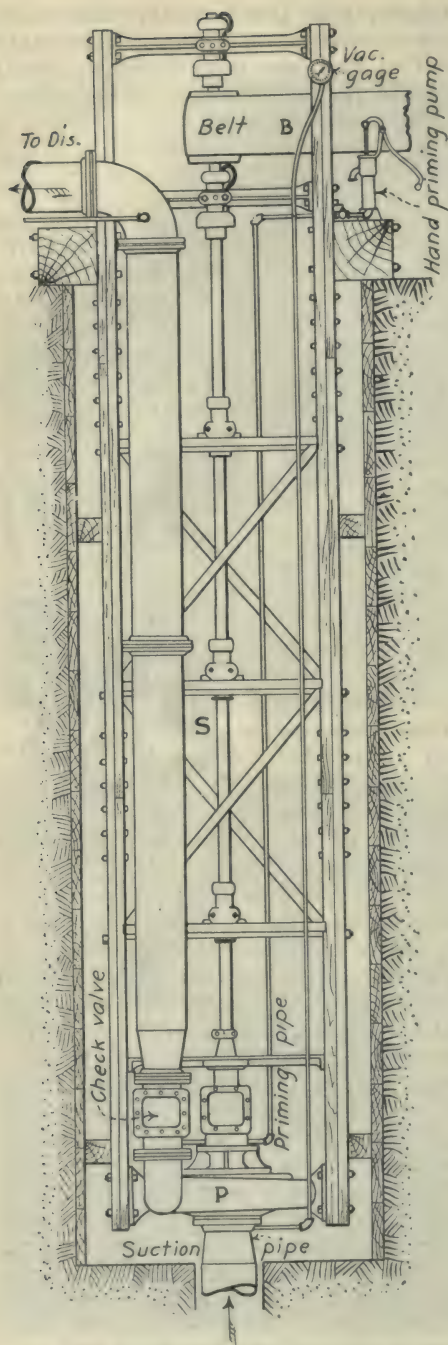


FIGURE 5.—Vertical centrifugal pump in pit. Pump P is operated through vertical shaft S by means of half-turned belt B

The vertical centrifugal pump is also used for irrigation. (Fig. 5.) In this pump the impellers are operated by a vertical shaft which may be of considerable length. The vertical type is used mostly for pumping from wells where the water level is so low that it can not be lifted to the ground surface by suction. The pump may be set in a deep pit below the ground-water level and run by a belt-driven pulley on top of the vertical pump shaft. Vertical centrifugal pumps cost about 50 per cent more than horizontal pumps of the same capacity and use about 10 per cent more power. To the cost of the pump itself must be added the cost of the pump pit and of the framework which holds the vertical shaft.

Where the suction lift is so great that hand-dug pits can not be used, a type of centrifugal pump known as the deep-well turbine pump (fig. 6) is employed. These pumps are so made that they can be let down to any depth in drilled wells of suitable bore. Deep-well pumps of large capacity cost from five to ten times as much as horizontal centrifugal pumps of the same capacity. To the cost of the pump must be added the extra cost of boring and casing the larger well made necessary by its use. Deep-well pumps are efficient when delivering 500 gallons per minute or more and give little trouble if properly installed. Except for rice fields, very few are used for irrigation in the Eastern States.

Centrifugal pumps used for farm irrigation usually are fitted with pulleys and are

belt-driven by gasoline engines, farm tractors, or electric motors. (Figs. 3, 4, and 5.) This is generally the best arrangement when tractors are used or when the pump must be set in a pit which at times is flooded. Where there is no danger of flooding, and pump and engine are not used for other purposes, direct-connected outfits (fig. 7) are to be preferred because there is no belt slippage and the system is more compact.

In choosing a pump for irrigation service a rugged, well-built machine should be selected. In the Eastern States irrigation pumps are used so few hours each year that the efficiency is of little importance as compared with reliability of operation. However, in certain cases a high-grade, efficient pump may be a better one to buy, as owing to its greater efficiency it may be possible to drive it with a smaller engine or motor and by this means justify its increased first cost and the more careful attention that must be given to it. Particularly is this true when such a pump makes it possible to use an engine or tractor already on hand.

Centrifugal pumps are designed for certain fixed lifts and work most efficiently at those lifts. The efficiency decreases if the pump is operated against a total head that differs from the designed head by only a small amount. For this reason the choosing of the right pump for the work to be done is important, and the dealers from whom cost estimates are asked should be given full information as to the lift and other conditions, and the specifications should be followed closely in installing the pump.

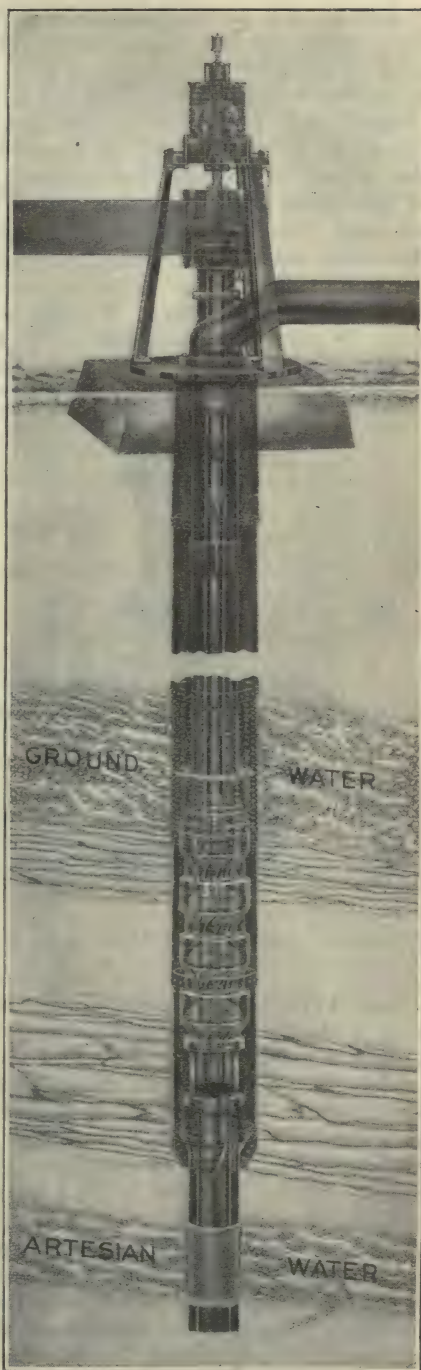


FIGURE 6.—Deep-well turbine pump, operated by half-turned belt

The air-lift pump (fig. 8) is another means of raising water from deep wells. It is a simple arrangement of piping whereby the water may be raised by compressed air. There are no working parts, and no valves except to regulate the supply of air. Besides the air compressor and power unit, the equipment consists of a drop pipe placed in the well with its lower end under water, and a small air line which carries the compressed air to a point near the lower end of the drop pipe. At this point the compressed air is discharged into the drop pipe, through a suitable outlet called the foot piece. Since the mixture of water and air in the drop pipe is lighter than the water outside the pipe which contains no air, the mixture rises to the ground surface. While the air lift is simple, it nevertheless must be correctly designed. The sizes of pipes and foot piece must be rightly proportioned, and the foot piece must be properly submerged.

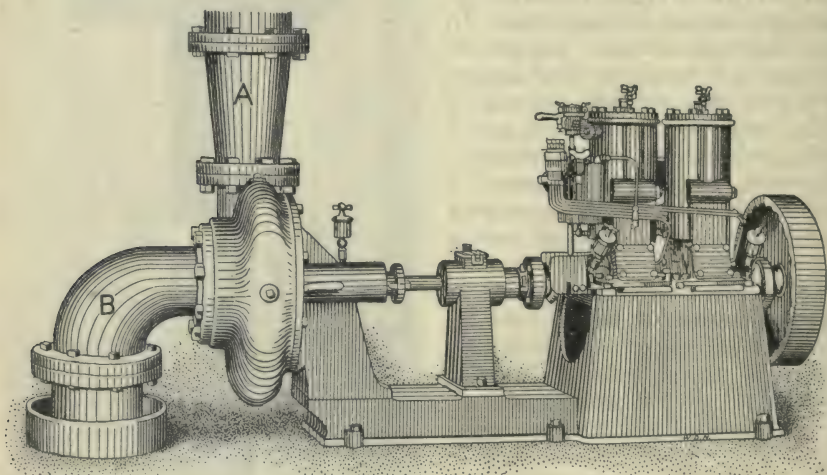


FIGURE 7.—Horizontal centrifugal pump direct-connected to 2-cylinder marine engine. A shows discharge and B suction pipe. Note taper of both

This type of pump is particularly suitable for pumping water from a number of scattered wells and for handling water containing sand and grit.

Plunger pumps are of three general types: Simplex (single cylinder), duplex (two cylinders), and triplex (three cylinders). They are especially useful for pumping from wells when the suction lifts are high. If in good condition, a plunger pump has a practical suction lift of between 20 and 25 feet. Owing to their high cost it is not likely that many new duplex or triplex pumps will be used for irrigation in the East, but for pumping up to 100 gallons of water per minute the double-acting pump with a single horizontal cylinder (fig. 9) is reasonable in price and satisfactory in operation. Particularly is this true of the latest forms of these pumps which are inclosed and self-oiling.

THE POWER UNIT

With the increasing use of electricity on farms electric motors will, without doubt, come into more general use for operating irrigation pumps, as they are so easily started, require little attention, and their first cost in sizes up to 15 horsepower is about that of gasoline engines of equal power. Above 15 horsepower the cost of the electric motor is generally less than that of the gasoline or

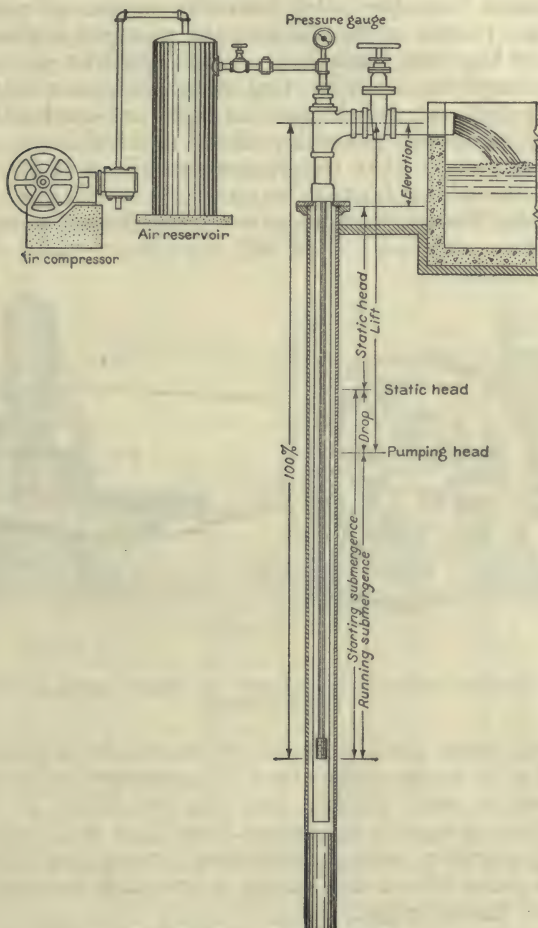


FIGURE 8.—Air-lift pump

kerosene engine. Owing to the shortness of the irrigation season and to the fact that pumping is done only occasionally, the cost of electric power with the considerable attendant charges made has, up to this time, generally been so high that comparatively few electrically driven plants have been used. Where the total charges are not too great, however, the electric drive proves satisfactory in every way.

If an electric pumping unit is used for pumping from a well where the suction lift from the ground surface is too great, the unit is sometimes placed in a pit at such a depth that the suction lift is not excessive. This arrangement, however, is not considered good practice owing to the dampness in the pit which is likely to destroy the insulation and damage the motor. A motor with windings protected with special moisture-proof compound should be used in such a case.

At the present time the most common source of power used in small irrigation plants in the East is the gasoline engine. (Figs. 7 and 9.) Many kerosene engines are used, however, as well as a few engines that burn the heavier fuel oils. Engines using gasoline, kerosene, and fuel oil are known as internal-combustion engines. Those using gasoline are generally of the smaller sizes.

It is very important that the engine be suited to the work to be done. The internal-combustion engine is not adapted to carrying heavy overloads; therefore an engine with sufficient power to handle the greatest pumping load that will be placed upon it should be

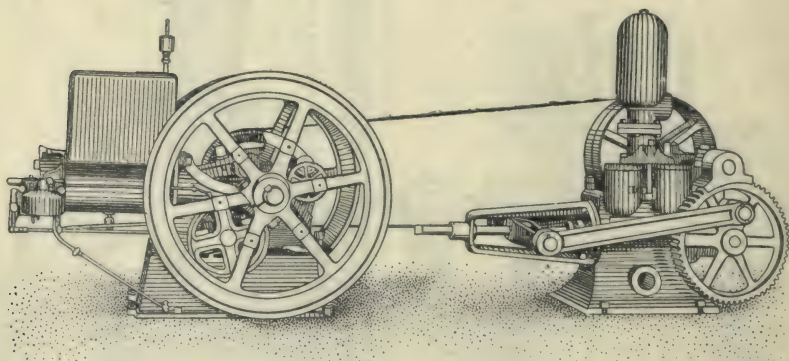


FIGURE 9.—Gasoline engine belt-connected to single cylinder, double-acting plunger pump

chosen. When crops need water they should be irrigated immediately. A reliable engine therefore is necessary—one that can be depended upon to start quickly and run steadily. In this connection the ignition system is important; one that will hold its adjustment for long periods without attention is very desirable. Sturdy, slow-speed engines which are easily lubricated generally give the best service for farm irrigation.

Engines suitable for eastern irrigation, ranging from 6 to 25 horsepower, can be purchased for about \$20 per horsepower. More powerful engines cost somewhat less per horsepower, while those of smaller capacity cost slightly more.

Sometimes second-hand automobile engines have been used for pumping, but unless good judgment is used in selecting the engine and in adapting it to the particular service in view it is likely to prove unsatisfactory.

The engine used with an irrigation plant often may serve other purposes, especially if it can be moved easily. The tractor therefore is particularly suited to this service. If the engine is already being

used on other work when the pumping plant is installed, the pump selected must be suited to the engine.

The size of the pump depends upon the time allowed for irrigating. The horsepower of the engine to operate the pump depends upon the quantity of water to be lifted, the height of the irrigated land above the water source, and the distance the water must be carried in a pipe. Table 1 shows the quantities of water needed to irrigate different acreages, the sizes of the pump, and the power necessary to irrigate those acreages. The total horsepower required may be found by multiplying the number found in Table 1 (column 9) by the total number of feet-of-lift. This total lift will be the lift from the water surface to the highest part of the land to be irrigated, plus the loss due to friction. The friction loss depends upon the size and length of pipe. This loss is shown in column 7 of Table 1 in feet of head per 100 feet of discharge pipe.

TABLE 1.—*Sizes of pumps and engines required for the irrigation of different areas*

Area	Water required per 2-inch irrigation	Capacity of pump per minute	Size of pump ¹	Kind of pump	Size of discharge pipe	Friction loss in discharge pipe per 100 feet	Efficiency of pump	Horsepower of engine per foot of lift	Approximate cost of pump ²	
									20 to 40 feet lift	40 to 100 feet lift
<i>Acres</i>	<i>Gallons</i>	<i>Gallons</i>	<i>Inches</i>		<i>Inches</i>	<i>Feet</i>	<i>Per cent</i>		<i>Dollars</i>	<i>Dollars</i>
$\frac{1}{4}$	13, 500	10	3 by 4	Single-cylinder double acting plunger.	1½	1.43	30	0.01	75	75
$\frac{1}{2}$	27, 000	10	do	do	1½	1.43	30	.01	75	75
1	54, 000	20	4 by 4	do	2	1.82	30	.017	90	90
2	108, 000	35	5 by 5	do	2½	1.72	30	.029	120	120
3	160, 000	35	do	do	2½	1.72	30	.029	120	120
4	210, 000	55	6 by 6	do	3	1.6	35	.040	165	165
5	270, 000	110	6 by 12	do	4	1.45	40	.070	220	220
			No. 2	Centrifugal	4	1.45	30	.093	40	100
10	540, 000	225-265	No. 3	do	6	0.74-1.06	35	0.166-.195	65	110
15	800, 000	300-375	No. 4	do	6	1.29-2.00	40	.185-.231	80	150
20	1, 000, 000	400-500	do	do	8	.56-.81	40	.247-.309	80	150
25	1, 300, 000	700-750	No. 5	do	8	1.54-1.74	45	.39-.418	100	250
30	1, 500, 000	700-750	do	do	8	1.74-1.74	45	.39-.418	100	250
40	2, 000, 000	900-1, 100	No. 6	do	10	.83-1.20	50	.456-.558	115	350
50	2, 700, 000	900-1, 100	do	do	10	.83-1.20	50	.456-.558	115	350
75	4, 000, 000	900-1, 100	do	do	10	.83-1.20	50	.456-.558	115	350
100	5, 400, 000	1, 200-1, 500	No. 8	do	12	.57-.85	55	.55-.68	235	500
200	10, 800, 000	1, 600-2, 200	do	do	12	1.00-1.78	55	.73-1.0	235	500

¹ Plunger pumps are rated by diameter of the plunger in inches, and the length of stroke in inches, which are the dimensions shown here. Centrifugal pumps of the cheaper grades ordinarily recommended for eastern irrigation for total heads up to 40 feet, are sold by number, which describes the diameter of the discharge pipe, in inches, at the pump. In the case of centrifugal pumps of the better grades and for the higher lifts, each pump is fitted to its work and the number of gallons per minute handled, rather than size of pump, governs. Purchasers should obtain a manufacturer's guaranty that the pump actually has the capacity represented under the given conditions.

² Prices are those quoted in 1929.

The figures in Table 1 apply to fairly stiff soils and to localities where the slopes of the land are such that the water can be handled without excessive waste. They allow for a total pumping capacity of 50,000 gallons per acre for one full irrigation. For a sandier soil—say where 100,000 gallons per acre is required—the figures in columns 2 to 11, inclusive, should be taken as for twice the acreage given in Table 1. Thus for 10 acres of a soil that is quite sandy the figures would be those given in Table 1 for 20 acres. In like

manner, for the types of soil that range between fairly stiff and quite sandy, the figures given in the table should be revised proportionately.

To illustrate the use of Table 1, suppose it is desired to irrigate 10 acres of fairly stiff soil under favorable conditions of slope. Suppose the highest point of the land to be 40 feet above the water supply, and that the pipe line from the pump to the land to be irrigated is 1,200 feet long. From the table it is seen that a No. 3 centrifugal pump will be needed. To find the horsepower necessary to operate the pump, determine first the total lift, which will be the difference in elevations, 40 feet, plus the friction loss. If 6-inch pipe is used, the friction loss, according to the table, will be 0.74 foot of lift for each 100 feet of pipe, assuming that the pump is operated at its lower capacity, 225 gallons per minute. There being 1,200 feet of pipe, the friction loss will then be $12 \times 0.74 = 8.88$ feet, so that the total lift will be $40 + 8.88 = 48.88$ feet. The total horsepower called for will then be $48.88 \times 0.166 = 8.11$, this being at the rate of 0.166 horsepower per foot of lift. A 10-horsepower engine would be recommended for this plant.

It would be possible to use smaller discharge pipe than the sizes recommended in Table 1, but if that were done more power would be required to force the water through it. Where conditions require the use of pipe smaller than shown, the matter of specifications should be referred to the pump or engine manufacturers, or to the United States Department of Agriculture.

The foregoing paragraphs and Table 1 will enable one to decide as to the kind and size of pump and power unit he will need, so that he can estimate the cost of this equipment. However, before a pump is purchased for an irrigation plant, any manufacturer whose product is being considered should be given full information as to the pumping requirements. These will include the number of gallons of water required per minute, the total pumping lift, whether the source of supply is a well or an open body of water, whether a belt connected or a direct-connected pumping unit will be needed. Of these items, the total lift is very important, and it is often the most difficult to estimate.

Unless a qualified engineer is employed to determine the lift, it is probably best to leave it to the manufacturer to estimate. To do this he will need to know the difference in elevation between the water level to be pumped from, and the open end of the discharge pipe; the size and length of suction pipe and discharge pipe; the number and kinds of fittings, including bends and reducing and enlargement fittings; also whether a foot valve is desired at the lower end of the suction pipe. If water is to be taken from a well, the manufacturer should be informed of the draw down (see p. 6) in the well when pumped to capacity, and the number of gallons per minute the well supplied under these conditions. It would also be well to inform the manufacturer that the outfit is desired for eastern irrigation conditions and that therefore it would be operated for only a few days each year.

With the above information any pump manufacturer should have no trouble in deciding on a suitable pump to offer for the job, and in determining the horsepower necessary to drive it. A pump should be purchased only against a satisfactory guarantee that it

will deliver the required number of gallons per minute when installed under the conditions named. It should not be paid for until it has been installed and tested and found to deliver water at that rate when driven by an engine or motor of the specified size. The easiest way to measure the quantity of water delivered will generally be by means of a weir (see p. 5) placed at some point near the open end of the discharge pipe.

INSTALLING THE PLANT

Generally the pump should be located as near the source of water supply as possible. Several arrangements of the pump and power unit are shown in Figures 1, 2, 3, 7, and 9.

The pump and engine should be placed upon a level and solid foundation, or upon two separate foundations if necessary. For the smaller engines and pumps, heavy wooden foundations will do. But for all permanent settings for medium-sized and large pumps and engines, good concrete foundations should be built, and they are much better even for the smaller ones. In constructing such a foundation for a pumping unit, or for pump and engine separately, the concrete base should be prepared with its top surface about one-half inch lower than the level at which the pumping unit is to be set. This is to allow for the final leveling and grouting as described later.

Upward through this foundation surface should project the threaded ends of the anchor bolts which are to hold the machinery in place. The threads on these bolts should be extended farther along the stem than is customary, and the bolts should stick up an inch or two farther than they are likely to be needed. They should be so located that when the machine is in place they will extend up through the bolt holes or slots of the bedplate far enough to receive the washer and nut. The head ends of the bolts, projecting through large-sized washers, should be set in the concrete with ordinary pipe thimbles large enough to allow a $\frac{3}{8}$ -inch or $\frac{1}{2}$ -inch clearance all around the bolt. The manufacturers of the pump and engine will furnish plans showing accurately the location of these foundation bolts, so that the foundation may be placed before the machinery arrives.

A 1:2:4 concrete (1 part of Portland cement, 2 parts of clean sand, and 4 parts of crushed rock or gravel) makes a good material for such a foundation if properly mixed and cured. Directions for mixing concrete are to be found in Farmers' Bulletin 1279, Plain Concrete for Farm Use.

After the concrete base has hardened, place the machinery upon it, bring it to the desired elevation and level it carefully in every direction by wedging under the bedplate. Now see that the revolving parts turn over easily. With a centrifugal pump it will generally be necessary to loosen the packing in the stuffing box. Do not, however, obtain ease of turning by loosening the bearings. When all strain is removed and the machinery is level, the rotating parts should turn easily. Fill in between the bedplate and the concrete base with the one-half inch or so of grouting that will be needed to give the bedplate a good bearing all around. This grouting may be made of a mixture of equal parts of cement and sand, with enough

water to make it work easily. When this has hardened tighten the foundation bolts, being careful not to spring the bedplate. After the bolts are tightened it is important that the rotating parts should still turn easily by hand. Be sure that this is the case. Again, after the piping has been attached to the pump it should be tested for ease of turning.

The whole pumping outfit should be protected from the weather and from dust and dirt. It should be housed in a building or room not used for any other purpose, and be so placed within this room that both pump and driver are easy to get at from all sides. If the power unit is a gasoline engine, the ignition system is likely to give the most trouble. Great care should, therefore, be given to its adjustment, and it should be carefully protected from moisture and dirt. If the power unit is an electric motor the windings must be kept dry. Before freezing weather sets in each winter all water should be drained from the pump and pipes, inside as well as outside the pump house.

PIPE AND FITTINGS

The pipe on both the suction and the discharge sides of the pump should be large enough to reduce friction loss as much as possible. The pipe used should never be smaller than the pump tappings, and for long lines they should be from one to two sizes larger. Great care must be used in tightening joints to see that no strains are put on the machinery.

All pipe lines should run as directly as possible and have no unnecessary bends. As a large part of pump trouble is found on the suction side, great care should be used to see that this is properly installed. As before stated, the pump must be well within the suction lift of the operating water level and a suction pipe at least one size larger than the pump intake tapping is desirable. The reduction in size of the suction pipe should be made at the pump connection, preferably by the use of a tapered fitting. (Fig. 7.) Such fittings may be obtained from the pump manufacturer. The joints must all be tight, as an air leak is fatal to good operation. If the pipe is not dropped directly downward from the pump into the water supply, it should at least be so sloped that there will be no pockets where air can collect. The lower end of the suction pipe should extend far enough below the water surface so that air will never be drawn in. For a small outfit pumping from a large body of water a 2-foot submersion will be ample. For larger pumps 4 feet or more will be needed, and when pumping from a sump or collecting chamber even greater submersion may be necessary, owing to the tendency of the water to cup down over the intake. In pumping from a well where a drop pipe is used, the lower end must be far enough below the water surface to make full allowance for the lowering of water level due to pumping. If pumping is to be from surface bodies of water a well-made strainer with ample openings should be provided to keep sticks and trash from being drawn into the suction pipe and thence into the pump.

On the discharge side of the pump the pipe may be of the same size as the pump fitting if only a few feet in length; if longer, it should be enlarged, and this should be done as near the pump as

possible, preferably through a tapered fitting. (Fig. 7.) The discharge pipe also should have as few bends as possible.

It is necessary to install certain valves and piping on the main water pipe lines around the pump. These valves are used in priming the pump and for protecting it from very high water pressures that may be set up accidentally. Where the discharge pipe is long a check valve should be placed in it near the pump. To protect a plunger pump a pressure-relief valve is desirable and always should be provided on the discharge side of a large pump of this type. When both a check valve and a pressure-relief valve are used, the former should be nearest the pump.

Before starting a centrifugal pump it is necessary to prime it. A common way of providing for priming, if the discharge pipe is short, is to place a gate valve in the discharge pipe, or a flap valve at its end, and a common hand pump at the pet-cock tapping in the top of the pump chamber. By operating the hand pump, with the valve closed, the air is exhausted from the suction pipe and pump chamber, and the pump filled with water. If the discharge pipe is long, it is only necessary to pump the air from the suction pipe and pump chamber, since the check valve (mentioned in the preceding paragraph) is automatically closed.

Another way of priming is to set a foot valve in the lower end of the suction pipe and then to fill the suction pipe and pump chamber with water from a barrel or tank placed at a suitable height. After the first priming each season this supply tank may be filled by a small branch pipe taking water from the discharge pipe. No hand pump is needed in this case, but it is very important that the foot valve have a water passage large enough for the regular pump operation.

Do not run a centrifugal pump empty, as water is depended upon for lubrication, and lack of lubrication even for a short time may injure the pump. Such a pump must be primed each time before starting. A gate valve in the discharge pipe near the pump, in the case of a centrifugal pump, is often necessary where there is difficulty in bringing the pump up to speed. Such a valve should be placed on the discharge side of the check valve. A by-pass suitably valved is a convenience with a plunger pump if there is difficulty in getting up speed.

BRINGING THE WATER TO THE LAND

DITCH SYSTEMS

If the water supply is to be brought to the field through an open ditch, the proper size of the ditch and its fall should be determined before excavation is begun. The size of the ditch will depend principally upon its slope and the acreage to be watered. Usually the grade is kept as flat as possible, both to prevent washouts and to deliver the water at a good elevation. If water is taken from a gravity supply and the diversion point on the stream is high the fall of the ditch often will depend upon the kind of soil. If the grade is made very steep in order to cut down the size of the ditch, trouble from washouts is likely if the soil is sandy or if the ditch is carried along a hillside. However, it is possible to protect such a ditch by lining it with concrete. Where there is no danger of injury through freez-

ing such a concrete lining may be a thin, plastered coating put on with a trowel, or a thicker lining may be applied if it seems necessary. Every effort should be made to so locate the ditch that it will be in the ground instead of on fills.

A small ditch can safely be carried on a steeper fall than a large one. Table 2 gives the quantities of water that ditches of various sizes and fall will carry safely in soils not classed as sandy. In sandy soils the side slopes of the ditches described in Table 2 might not stand. In that case it would be necessary to make the ditch wider and shallower, and with a slightly greater cross section in order to carry the same amount of water at the same grade. To aid in doing this, the cross-sectional areas of ditches of different sizes are given in Table 2 for making comparisons. The distribution ditches should be located on the higher parts of the field to be irrigated, either along its high side or along the tops of the ridges that may extend into it.

TABLE 2.—*Carrying capacities of ditches*

Size of ditch	Fall	Carrying capacity	Size of ditch	Fall	Carrying capacity
	<i>Inches per 100 feet</i>	<i>Gallons per minute</i>		<i>Inches per 100 feet</i>	<i>Gallons per minute</i>
Top width 2 feet, bottom width 1 foot, depth 6 inches, cross-sectional area 0.7 square foot.	4 6 8 12 18	340 410 480 590 720	Top width 4½ feet, bottom width 2½ feet, depth 1 foot, cross-sectional area 3.5 square feet.	1 1½ 2 3	1,460 1,790 2,070 2,550
Top width 3 feet, bottom width 1½ feet, depth 9 inches, cross-sectional area 1.7 square feet.	2 3 4 5 6	760 930 1,070 1,200 1,320	Top width 5½ feet, bottom width 3 feet, depth 1 foot 3 inches, cross-sectional area 5.3 square feet.	1 1½ 2	2,620 3,220 3,730
Top width 3 feet, 8 inches, bottom width 2 feet, depth 10 inches, cross-sectional area 2.3 square feet.	2 3 4	1,190 1,460 1,690	Top width 7 feet, bottom width 4 feet, depth 1½ feet, cross-sectional area 8.2 square feet.	¾ 1 1½ 1¾	4,150 4,800 5,900 6,380
			Top width 9 feet, bottom width 5 feet, depth 2 feet, cross-sectional area 14 square feet.	¾ 1 1½ 2 3	6,080 7,070 8,700 10,070

To handle the water as it comes from the larger supply ditches, several small structures are needed. It may be well to use wooden structures until the system has been tested thoroughly.

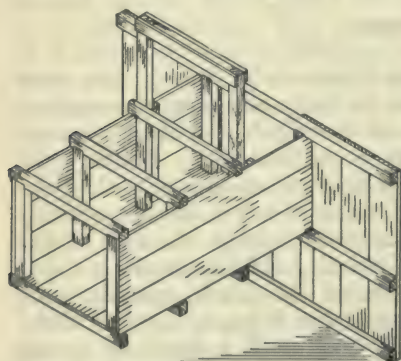


FIGURE 10.—Wooden head gate with one outlet

A wooden head gate usually is put in where a small ditch is taken from a main. Such a structure (fig. 10) may have 1, 2, or 3 outlets. The water is controlled best by means of movable boards fitted into cleats nailed to the side of the box. Small ditches, however, generally call for such structures only at the intake. At other points the water may be controlled either by filling the ditch with dirt at the proper places, and cutting the bank with a shovel or by using canvas or sheet-iron dams that can be

moved around as desired. (Fig. 11.) In using the canvas dam the irrigator places the top slat across the ditch and throws a little dirt on the canvas at the bottom and sides. The sheet-iron dam is merely thrust into the ditch deep enough to stand the pressure of the water against it.

The common way to take water from a small ditch at the heads of the furrows is to cut small trenches through the side of the ditch with a hoe or a shovel. A better method calls for the use of lath spouts or pieces of pipe placed in the banks of the ditch. (Fig. 12.) The quantity of water let into each furrow may be regulated either by a cloth flap over the intake end of the lath spout, or preferably by means of a small tin or galvanized sheet-iron gate or slider. Where a pipe spout is used water may be controlled by means of a single thrust into the earth in front of the pipe.

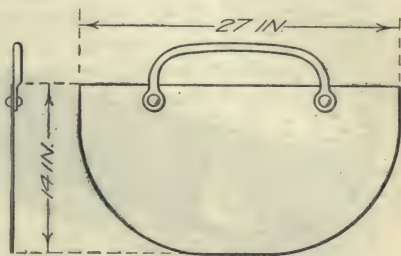


FIGURE 11.—Metal dam or tappoon

VITRIFIED SEWER-PIPE SYSTEMS

Under some conditions a satisfactory distribution system may be built of vitrified clay sewer pipe, also called terra-cotta pipe or salt-glazed pipe. This pipe can be made water-tight under low pressure and can be laid by anyone who is willing to use the necessary care. A sewer-pipe line should not be used for a vertical head of water of more than 15 feet, which means a pressure of 6 pounds per square inch. It may be laid over ridges and across depressions if the total safe head is not exceeded. As is done with open ditches, distribution pipe lines are laid along the highest side of the land to be irrigated, and the water is let out at convenient points. Often it is possible to lay the pipe on top of a ridge across a field and run the water down both slopes.

None but the best grade of sewer pipe should be bought for this use. Pipe with cracks or broken ends should be rejected. The best way to test for cracks is to tap the pipe lightly with a hammer, a clear ring usually meaning a sound pipe. Pipe which is not well formed also should be rejected.

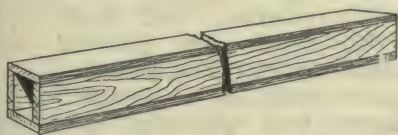


FIGURE 12.—Lath pipe for ditch bank

The trench in which the pipe is laid should be dug deep enough to allow at least 18 inches of earth cover over the pipe after it is laid. This is to prevent injury to the buried pipe when a heavily loaded wagon or a tractor passes over it. The bottom of the trench should be scooped out to a rounding surface to bed the pipe properly. This is most easily done by digging a flat-bottomed trench and then scooping out a central channel with a tile scoop to a depth of one-third the outside diameter of the pipe. (Fig. 13.) The flat-bottomed part of the trench should be dug about a foot wider than the outside width

of the pipe to allow the worker to move about in the trench without disturbing the pipe previously laid. As the pipe is laid hollows should be scooped out for the pipe bells so that a considerable part of each pipe will bed firmly in the trench. (Fig. 13.) In back filling the trench the earth should be carefully tamped around the pipe.

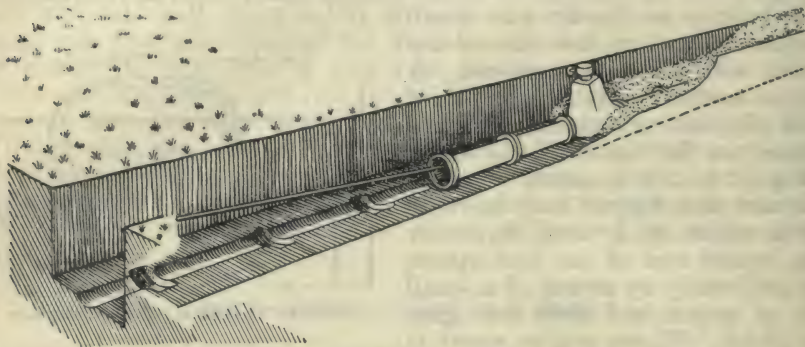


FIGURE 13.—Installing vitrified sewer-pipe distribution system

Joints may be made either with cement mortar or with bituminous sewer-pipe joint compound. Most irrigators now use both materials, making one to four joints of the compound and then one of cement mortar. The advantage of this is that the bituminous compound is elastic enough to allow some give in the pipe line due to settling, temperature changes, etc. Also, farm workers seem better able to

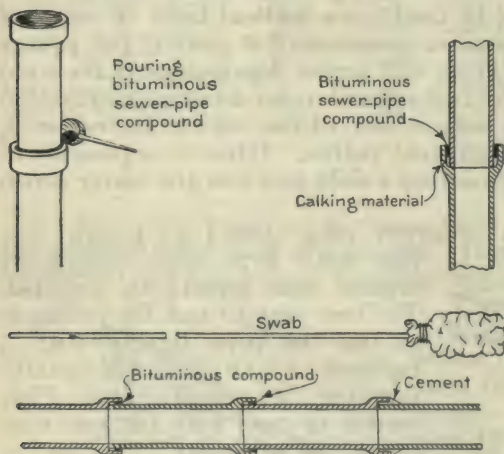


FIGURE 14.—Method of assembling vitrified sewer-pipe unit

make good cement joints than bituminous joints, when the pipe is lying in the ditch. The method usually followed is to join two to five lengths of pipe outside the ditch and then lay the assembled unit. These units are readily made by stacking the lengths in a vertical position, bell ends upward, and pouring the melted bituminous material into the joints. Before pouring, however, the lower part of the space between the bell of one pipe and the spigot of the next should be well

calked (fig. 14) to prevent the melted joint material from running out and wasting. For calking, jute often is used but pieces of newspaper crumpled up and carefully tamped into place answer very well.

Better joints are required for this work than for ordinary sewer work. Therefore not over one-third the depth of the bell should be filled with calking material, at least two-thirds being left to be filled

with the joint material. The heavier grades of bituminous sewer-pipe joint compound should be used, the grade that weighs about 108 pounds per cubic foot being very satisfactory. About one-fourth pound per inch of pipe diameter will be needed for each joint. The material should be melted in a kettle and heated until it pours like water. It is important, however, not to heat it above that point. A skillet or ladle may be used for pouring.

After the joints have cooled the assembled units of several pipe lengths may be laid. But before this is done the bell holes should be scooped out of the trench. The correct locations for the bell holes may be most conveniently spotted by the use of a straight stick properly marked off.³

When the new pipe unit is in place it should be joined with a water-tight joint, usually of cement mortar, to the pipe already in place. For good cement joints it is important that the entire joint space be filled with the cement mortar; this requires that the mortar be tamped firmly into the bell. Great care should be taken to make sure that the under side of the joint is well cemented. To do this effectively it often is necessary to use a tamping tool. Such tools may be made of iron, but very satisfactory ones can be whittled out of wood. To smooth up the inside of the pipe in case any mortar works into it, a long-handled swab (fig. 14) made of gunny sack-ing so as to fit the inside of the pipe should be provided. This swab is allowed to lie in the pipe with its handle projecting outside as shown in Figure 13. When a section of pipe is added it is slid over the swab handle, and the swab is always drawn toward the open end of the pipe.

The mortar for the joints should be made of clean, sharp sand mixed with an equal quantity of cement and only enough water to make the mixture fairly stiff. Only small batches should be mixed at a time, and these should be used quickly; it is not wise to use mortar that has stood longer than 15 minutes.

The outlet valves or hydrants are commonly spaced from 30 to 100 feet apart and are connected by short lengths of clay pipe to standard sewer-pipe tees placed in the main pipe line as it is laid. Each outlet is cemented firmly to its short riser pipe. In the best class of work a block of concrete is then cast around the tee and its short pipe, thus reinforcing the entire connection with the main. (Fig. 13.) Where the soil is likely to freeze, this block of concrete should always be tapered toward the top, to guard against heaving.

Four-inch iron pipe nipples for outlets, and 4-inch cast-iron pipe caps to shut the water off when it is desired to close the outlets (fig. 15) are sometimes used. Such openings are cheap, but the

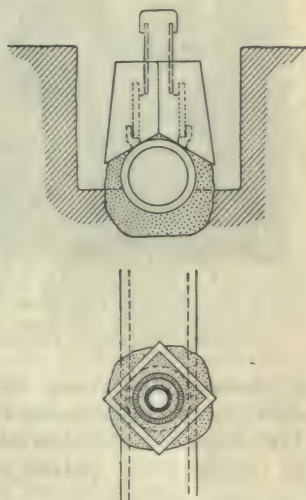


FIGURE 15.—Nipple and cap outlet from vitrified sewer-pipe distribution line

³ One contractor who has done a considerable amount of this work beds the pipe with the aid of water instead of scooping out for the bells. After the pipe is laid and the joints tested he throws in enough dirt to cover about three-fourths of the pipe. He then feeds the ditch and after the earth has dried sufficiently he tamps it under the pipe.

irrigator is likely to be sprayed with water when closing an outlet. Furthermore, it often is difficult to remove the caps because of rust. Trouble from this cause may be reduced by frequently coating the threads with graphite grease.

A better type of outlet is shown in Figure 16. It is usually cemented to the inside of the bell of the riser pipe. The valve

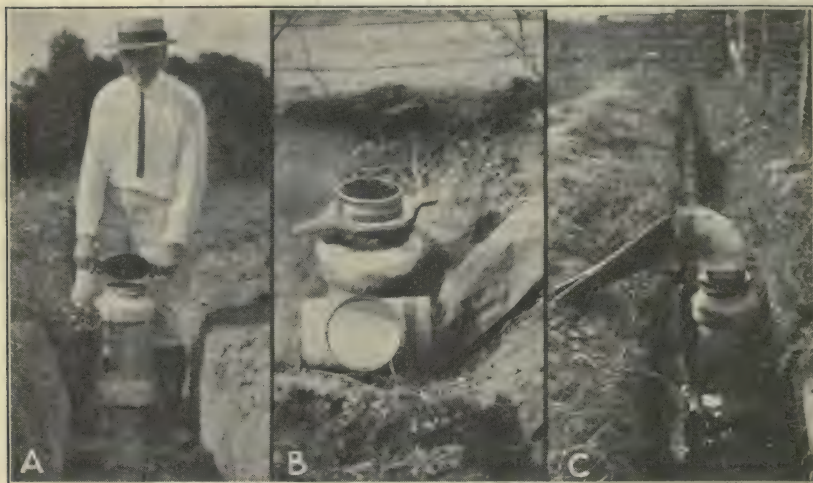


FIGURE 16.—Quick-acting irrigation valve for sewer-pipe system: A, valve with its cover removed, also short riser pipe connecting valve with main; B, valve with part of portable tee hood attached, showing its separable feature; C, valve with portable elbow hood attached. The elbow or tee may be pointed in any direction

is closed by placing the cover over the opening and giving it a short, quick turn to the right, and is opened by reversing the process. This type of outlet may be used successfully where it is not necessary to regulate the quantity of water leaving the valve. Where regulation is desired a 4-inch or even a 3-inch

steel pipe nipple with gate valve may be used (fig. 13), or an alfalfa or orchard valve (fig. 17) such as is used in the concrete-pipe irrigation systems of the West.

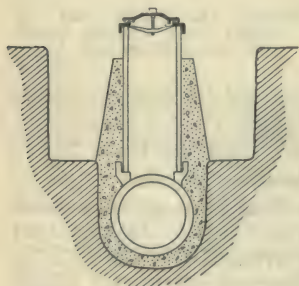


FIGURE 17.—Alfalfa or orchard valve outlet from sewer-pipe distribution line

Usually, water is allowed simply to spill from the top of the valve into a ditch from which it is taken out through one or more openings in the ditch bank for broad flooding or through many openings for furrow irrigation. In the latter case, the flow in each furrow is regulated with a shovel or by means of short lengths of iron or lath pipe, as previously mentioned.

Where it is desired to use portable pipe (p. 30) a special portable hood is necessary. (Fig. 16.) Hoods arranged to fit the commercial irrigation valves may be purchased from the valve makers, but if outlets made of pipe fittings are used, each irrigator must devise his own. Only one portable hood is needed for a number of valves.

Either one of the hoods made to fit the valve shown in Figure 16, clamps to the valve casting in the same way as the cover. The sheet-iron connecting piece, with its short canvas hose attached, may be turned in any direction.

Generally it is unwise to use sewer pipe under pressure where the ground freezes to a depth of more than a foot. In any case the top of the pipe should be at least a foot below freezing, as considerable changes in temperature seem to cause trouble in sewer-pipe lines even though the pipe is buried below danger from heaving ground. The uprights leading from the main to the surface must be protected; otherwise heaving of the ground due to frost often will break the connection between the valves and the underground main. The tapered concrete block recommended on page 23 is designed in part to overcome this trouble. There should never be any projecting shoulder for heaving ground to raise; any valve with projections should be placed several inches above the ground.

Sewer pipe when used in the Northern States should be laid at such slopes as will permit it to be drained easily. Drain cocks may be placed in the pipe at low places, these being made by cutting a hole in the pipe with a cold chisel at each low point and cementing in a short piece of 1-inch iron pipe connected to a cut-off valve, or closed with a cap. The drain is set near the bottom of the pipe.

It is not safe to pump directly into a sewer-pipe system unless some sort of pressure-relief device is provided. The surest device for this purpose is an open standpipe (fig. 18) with its top at an elevation a few feet above that of the highest ground to be irrigated. Then if the pump is operated with all the valves closed the standpipe will permit the water to overflow, thus preventing the pressure from bursting the pipe. Such a standpipe should be placed between the pump and the sewer-pipe line; it should be placed on the discharge side of the check valve if one is used. Similar standpipes should be placed near the closed ends of long laterals as well as of all laterals of even moderate length if the far ends are at low elevations. A cheap and convenient standpipe may be made by cementing together a few joints of pipe, as shown in Figure 18. Sometimes large standpipes (18 inches or more) are constructed in the field to act as diversion boxes or junctions where branches are taken off. Usually they are fitted with slide gates and serve as a means to shift water from one lateral to another. Such a diversion box is shown in Figure 19.

Often where gullies must be crossed, provision must be made to get water to higher land without putting too much pressure on the sewer pipe at the low point. This may be done by bringing the pipe above ground and supporting it on a trestle where it crosses the low ground. Where a trestle would be inconvenient it may be desirable to use underground pipe of other material capable of standing higher pressure.

Sometimes it is possible to use a combination system of sewer pipe and open ditch, the pipe being used to carry water over rough or gravelly ground, or across small ridges or hollows. The ditch then may be used to carry the water over parts of the farm where the slopes are suitable and where open ditches would not be wasteful of water nor interfere with teaming. Water can be taken into the furrows either from the ditch or from the pipe. The combination often

will mean a considerable saving in the cost of the distributing system. The combination system, however, calls for the use of somewhat larger pipe than would be the case in a pipe system, as only gravity pressure is available. The use of open ditches is in no case advisable if the soil is so sandy or porous that much waste by seepage would occur.

CAST-IRON PIPE SYSTEMS

The thinner types of cast-iron pipe are well suited for use in most eastern irrigation systems, either for the complete piping layout or for only the high-pressure parts. Cast-iron water pipe class A or



FIGURE 18.—Relief standpipe. Where not more than three lengths of pipe are used the supporting tower is not needed

class B, standard cast-iron gas pipe, or extra-heavy cast-iron soil pipe, all are suitable for this use. For irrigation service it is proper to use the soil pipe for heads up to 100 feet, the gas pipe and class A water pipe up to 150 feet, and class B water pipe up to 250 feet. Soil pipe is furnished in 5-foot lengths and the others in 12 and 16 foot lengths. In any case, bell-and-spigot pipe, and not flanged pipe, should be used, and because of the saving in labor required for jointing the longer lengths are preferable. Instructions for making joints are given in Farmers' Bulletin 1426, Farm Plumbing. Cast-iron pipe should be covered at least 15 inches over its top, and where it passes under farm roads it should be protected from injury by the wheels of heavily loaded wagons in case ruts form.

Outlets for cast-iron pipe lines should be spaced 30 to 100 feet apart as for sewer-pipe systems. An outlet is conveniently made by inserting a short piece of standard wrought-steel pipe into the side bell of a cast-iron tee, and using a standard valve to control the discharge. A 3-inch valve ordinarily is large enough for an outlet. A bushing, in addition to a nipple and valve, may be necessary if cast-iron tees with 3-inch side outlets are not obtainable. The same joint material as is used for the other joints in the system may be employed to attach the wrought-steel pipe to the cast-iron tee. Usually, no pressure-relief arrangements are necessary if water is supplied by gravity, by city main, or by a centrifugal pump; but if supplied by a plunger pump a suitable relief valve should be provided at some convenient point, or an open standpipe erected at the highest place in the pipe line. If there is danger from freezing, the pipes should be so laid that they may be drained at all low points. At each of these places a hole should be drilled in the lower part of the pipe and tapped for a 1-inch standard pipe fitting, and a plug or stopcock inserted.

OTHER PIPE SYSTEMS

Cast-iron pipe is the most durable of all metal pipes used in irrigation. Galvanized and black wrought-steel pipe generally is the most quickly obtained and installed and where these factors are more important than the extra cost it is good pipe for irrigation purposes. Galvanized lightweight riveted-steel pipe is satisfactory where it can be supported above the ground, as along fence lines. Wood pipe has many good points for irrigation service, but the problems of protecting it from early decay are serious. High-grade concrete pipe—both plain and reinforced—is suitable for irrigation work and is widely used in the West. In the East, the cost of such pipe has, up to the present time, prevented its extensive use in irrigation, but this objection is now being overcome, and some concrete-pipe systems recently have been installed. Bell-end pipe, installed in the same manner as suggested for clay sewer pipe, is recommended.

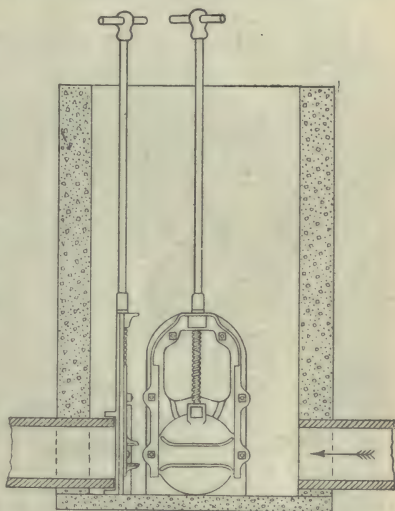


FIGURE 19.—Combination standpipe and diversion box, built of concrete

APPLYING WATER TO CROPS

A certain degree of skill is necessary to irrigate properly by any method. This can be attained only by practice. Therefore the amount of water to apply and the exact procedure in applying it can not be definitely set down in words. While it is likely that the observant eastern farmer with his frequent opportunities to watch the effect on his crops of the varying moisture conditions is not likely

to go far astray in judging when the proper moisture condition has been attained by his irrigation practice, yet certain principles may be of aid to the beginner.

FURROW IRRIGATION

In furrow irrigation the water is generally diverted from the distribution system into head ditches and from them into the field furrows. (Figs. 20 and 21.) A sandy loam underlain by a tight subsoil probably is the easiest and most satisfactory soil to irrigate by this method, if the slope of the land is favorable. Such a soil, with a slope of from 4 inches to 1 foot per 100 feet, will allow water to reach the plant roots and still run a considerable distance down open furrows.



FIGURE 20.—Furrow irrigation. Water is being delivered from a specially designed outlet valve which is connected to underground sewer-pipe system

The amount of moisture in the ground before an irrigation is begun and the kind of crop grown will largely determine the quantity of water to be used in that irrigation. In light, loamy soil the water may be applied by running it for only a short time in each furrow, but a much longer time will be required for a heavy soil. Usually water should be let into each furrow and made to reach the lower end as quickly as possible; the quantity entering each furrow can then be decreased as necessary, although the regulation should be such that a sufficient supply will always reach the end of the furrow. This method may be expected to give the most uniform distribution of the water.

The irrigator can determine whether the water has run long enough by digging down to the roots of the plants, at several points along a row, and noting the depth the water has reached. If it has gone below the root zone, water is being wasted. It is best not to

wet the surface of the ground in the row of plants, but to allow the water to seep into the soil from furrows or middles between the rows. This will prevent the soil in the rows from later baking and cracking.

Very sandy soil usually requires that a large quantity of water be applied to each furrow, as it is necessary to get the water to the lower end of the furrow quickly to prevent loss by deep seepage. The slopes of the ground will affect the rate of applying water. If it is put on too rapidly the soils will wash badly on steep slopes, and if the ground is flat the water will not reach the ends of the furrows but will form puddles at the upper ends. Washing may be overcome either by letting smaller quantities of water into the furrows, or by decreasing their slopes by running them diagonally



FIGURE 21.—Furrow irrigation from open-ditch system

across the field. For very flat slopes it often is necessary to use the portable pipe or hose later described.

Heavy clay soils usually require that smaller quantities of water be applied in each furrow; the furrows should be deep and narrow, and the water should be run for a longer time. Such soils call for less water for each irrigation, and they hold the water better than the sandy types. However, the irrigator must watch each furrow very carefully or he will waste water at the lower end. For heavy soils it is highly desirable that the distributing apparatus be such that it may be adjusted closely, so that the water will be divided equally among a large number of furrows.

Unless the plants completely shade the ground cultivation is very necessary after each irrigation and should follow as soon as the condition of the soil will permit.

If the ground is dry at the time of planting, some irrigators plant in furrows which have been wetted down previously by irrigation; others plant between furrows that are close together, and then allow the water to run long enough to soak the seed bed thoroughly.

Often, furrows 400 to 600 feet long (and sometimes even longer) may be used satisfactorily, but generally shorter lengths are advisable. If the furrows are found to be too long it may be necessary to run another pipe line or ditch parallel with the head line, about halfway down the furrows. In small market gardens the furrows often are not over 100 feet long. If the furrows are shorter the water may be controlled more satisfactorily, and less waste will occur.

Where a combination of spray and furrow systems seems necessary, the former should be used to irrigate seed beds or closely planted garden truck, and the furrow system for such crops as potatoes, sweet corn, Lima beans, rhubarb, and berries, as well as celery after it has been set out from the seed beds. It may be practicable to do without the spray system if the seeds are planted in beds 3 to 10 feet wide which may be irrigated from furrows cut between them. The water should then be kept in the furrows long enough to allow it to seep across the beds. This method may be followed on land that is nearly level, provided that the surface soil is light and that it is underlain by heavier soil. Furrow irrigation of seed beds on heavy clay soils is very difficult and requires considerable patience and experience.

USE OF PORTABLE PIPE AND HOSE

If the soil to be irrigated is very sandy, or the land is too flat to permit the water to run down the rows or furrows, or the quantity of water is limited, the use of portable pipe may be desirable. Portable pipe usually is made in 10-foot sections of lightweight sheet iron, one end of each section being slightly tapered so that it may be pushed into the untapered end of the following section to make a fairly tight joint. The pipe should be made of 24 to 26 gauge galvanized sheet iron for 6-inch and smaller sizes, and of 22 to 24-gauge for 8 and 10 inch sizes. It is important that the ends of portable pipe be reinforced, as otherwise the pipe often is ruined by the breaking of the seams when the sections are being connected or disconnected. This reinforcing should be done with iron of not less than 18 to 20 gauge. Several firms make this pipe, and local tanners usually can make it or order it for the irrigator. Some prefer the less durable but more easily obtained conductor pipe, which generally is used in the 3 or 4 inch size.

Homemade canvas hose about 10 feet long is used to connect the outlet hood with the nearest section of portable pipe. (Figs. 16, C and 22.) One end of this hose is connected to the hood discharge, generally by tightly wound wire, and the other end is simply thrust into the nearest end of the portable pipe. Such a connection is quickly made and is very flexible.

In use, the portable pipe may be built up section by section as irrigation proceeds, or the entire length may be built up first and the sections disconnected as necessary. When the limit of one setting of the portable pipe line is reached, the operation is repeated with a new setting of the pipe. Portable pipe is very convenient for irrigating hay crops and is used extensively in the West for irri-

gating alfalfa where the soil conditions are not favorable for wide flooding. (Fig. 23.)

On account of leakage it is very difficult to force water even a few inches uphill through ordinary portable pipe. Some eastern irri-



FIGURE 22.—Irrigating with 6-inch portable pipe, showing the first length of portable pipe and the homemade canvas hose that connects it with the outlet hood

gators have reduced leaks at the joints by laying the pipe at a uniform slope, using portable wooden trestles where necessary. (Fig. 24.) One way of reducing leakage is to have two or three lugs



FIGURE 23.—Use of portable galvanized-iron pipe in alfalfa irrigation

firmly attached near each end of each section of portable pipe and to fasten the sections of pipe together with a turn of hay wire when applying water to higher ground. Only a small rise in ground sur-

face can be overcome by this method. Another plan is to have the tapered and reinforced ends of the sections extra long and heavy and to use lugs containing bolt holes. Bolts can then be put through the lugs and the pipe drawn up with nuts, usually making a fairly tight joint. Western irrigators have used tarred cloth or burlap between the taper and the ring. Where water must be forced up a considerable slope it sometimes is necessary to obtain extra-light spiral-riveted pipe and to use a bolted joint. The time necessary to make connections renders this method too slow, however, if the pipe needs to be carried from place to place very often.

Hose is sometimes used instead of portable pipe to convey water. However, it is not as durable as pipe and is soon worn out by being dragged over the field. It is subject also to attack by insects, rats, and mice, when stored for the winter, and is hard to handle unless the diameter is small and the lengths are short. Hose will drag down tender plants unless it is handled very carefully. If used at



FIGURE 24.—Portable galvanized-iron pipe line supported by wooden trestles

all, it should be dried out after each irrigation and stored in a dry place.

For small quantities of water ordinary garden hose can be used. Condemned fire hose, up to $2\frac{1}{2}$ inches in diameter, sometimes can be bought cheaply. The connections on fire hose are of the quick-turning variety. Fifty-foot lengths usually are best. Cheap 2 to 8 inch hose may be homemade from strips of heavy duck or canvas by sewing a double seam with very heavy thread. A local harness maker or cobbler who has suitable machines for such work should be able to make a strong hose of this sort. The canvas hose may be joined by simply shoving the discharge end of each 50-foot section about 3 feet into the next length. The pressure of the water tightens the connection. In irrigating, the hose sections may be separated by a simple jerk.

FLOODING AND CHECK METHODS

The flooding method consists merely in permitting the water to flow more or less uncontrolled over the land, generally from open-

ings cut in the banks of open ditches. Though apparently simple, this is generally a laborious process, owing to the amount of shovel work required and the necessity of wading in the saturated ground. This method is illustrated in Figure 25.

The check method of irrigation, which in the humid section reaches its widest use in the irrigation of rice, consists in flooding "checks" formed by small dykes or levees located on contours (the lines joining points of equal elevation) at about 3 to 6 inch differences of elevation and suitably connected by cross levees. These checks usually vary in size from about one-half acre to several acres. Directions for laying off and building checks are contained in Farmers' Bulletin 864, Practical Information for Beginners in Irrigation. This method with modifications is also used for the irrigation of cranberries.



FIGURE 25.—Flooding from an open ditch

COST OF IRRIGATION ⁴

At present the most important item of expense for irrigation in the Eastern States is the cost of the plant. This may amount to only a few dollars per acre irrigated where a gravity flow is available and water is distributed to the field entirely through open ditches. In a number of such cases, especially in the South, considerable areas have been watered for \$10 or less per acre. Those systems required only short gravity ditches leading directly from streams or flowing wells. A more expensive plant is necessary where the water supply must be stored. Systems using flowing wells that yield only 40 to 60 gallons per minute have been used to irrigate 10 to 20 acres, with the assistance of storage reservoirs constructed in clay soil.

Irrigation plants with low pumping lift and open-ditch distribution systems also are comparatively cheap. An open-ditch system

⁴ Cost figures given are based upon prices quoted in 1929.

to irrigate a 20-acre field adjacent to a stream should cost, installed, not more than \$20 to \$25 per acre, if the pump is to be operated by a tractor whose cost is already charged to some other item of farm operation. Areas larger than 20 acres, under the same circumstances, could generally be irrigated at somewhat lower costs per acre. A similar plant for a field of 100 acres should not cost over \$17 or \$18 per acre.

A complete sewer-pipe distribution system for a 20-acre field with a near-by water supply might cost as much as \$80 or \$90 per acre for tractor operation, and if equipped with a farm engine \$10 or \$12 more per acre if the lift were less than 30 feet, or \$20 to \$25 more per acre if the lift were between 30 and 60 feet. Under the most favorable conditions, where the irrigation water could be run long distances in the furrows, such a plant might be installed for as little as \$45 per acre for tractor operation. On the other hand if the pump lift were, say, 70 feet and the field were 1,000 feet from the water supply, another \$60 to \$90 per acre might easily be added to the cost of the outfit although the cost of the field-distributing system should be about the same as for the lower lift. As in the case of the open-ditch system it should be possible to install a system for more than 20 acres at correspondingly lower costs.

Where a well must be bored and a deep-well pump installed, the simplest irrigation system probably would cost not less than \$100 per acre, even for tractor operation.

Table 3 shows costs of pipe of various kinds adapted to use in surface irrigation which, together with the pump-cost figures shown in Table 1, and the engine costs given on page 14, should enable one to estimate the approximate cost of a complete irrigation system. The prices shown in Table 3 are subject to wide changes, and one who is considering irrigation should inform himself as to current prices.

TABLE 3.—Approximate cost¹ per foot of pipe adapted to surface irrigation systems

Diameter	Kind of pipe				
	Sewer pipe	Cast iron, class A	Cast iron, extra heavy soil	Wrought steel, black	Wrought steel, galvanized
<i>Inches</i>	<i>Dollars</i>	<i>Dollars</i>	<i>Dollars</i>	<i>Dollars</i>	<i>Dollars</i>
$\frac{3}{4}$				0.06	0.08
1				.09	.11
1 $\frac{1}{4}$				.12	.14
1 $\frac{1}{2}$				.14	.17
2			0.20	.19	.23
2 $\frac{1}{2}$				.28	.36
3		0.36	.31	.38	.48
4	0.11	.50	.42	.55	.68
5		.63	.64	.74	.92
6	.13	.77	.63	.96	1.19
7				1.19	
8	.21	1.05		1.25	
10	.28	1.40		1.60	
12	.37	1.75		2.25	
15	.54				

¹ Based on prices quoted in 1929

Suitable outlet valves can be obtained at prices ranging from \$1.50 to \$6 each. Trenching and laying should be done for from 8 to 12 cents per running foot for the sizes ordinarily used in the East, the higher cost applying to clay soil where trenching is expensive.

The operating cost of most furrow-irrigation plants in the East is not great, as crops ordinarily need to be irrigated only a few times each season to carry them through periods of drought. At 25 cents per gallon for gasoline and 25 cents per quart for lubricating oil the annual operating costs should not exceed \$5 per acre per year for a 50-foot lift, or \$10 per acre per year for a 100-foot lift in the case of a 20-acre plant, and for larger outfits they should be less. This assumes that the engine attendant does other farm work primarily and that no labor charge is made against ordinary operation. However, the interest on first cost and the depreciation of the plant must be considered carefully as these items often are the deciding factors in determining whether a pumping outfit will pay. Yearly interest and depreciation would range from 10 to 20 per cent; perhaps an average of 15 per cent would hold for most surface-irrigation plants. Field-labor charges are important and must not be neglected. One man usually is able to irrigate from $1\frac{1}{2}$ to 3 acres per day by the furrow method, and somewhat less by portable pipe.

Example 1.—If an outfit will cost \$75 an acre to install complete with engine or motor, and it is decided to allow 20 per cent for interest, taxes, and depreciation, it is then necessary to figure $\$75 \times 0.20 = \$15$ annually for these items with, say, \$10 per acre per year for fuel and \$5 per acre per year for repairs and incidentals. In addition to this, there will be an expense of perhaps \$5 per acre per year for field labor (assuming that labor will cost \$4 per day, that a man will irrigate 2 acres per day, and that two and one-half irrigations per season will be the average need). The average annual cost per acre chargeable to irrigation, then may be expected to be $\$15 + \$10 + \$5 + \$5 = \$35$. This means that before any profit can come from the irrigation investment the crops irrigated must yield an average of \$35 per acre more than those raised on the same land without irrigation. A yield of less than this amount during some years would be permissible if much more is received in others, provided the proper average is maintained.

Example 2.—Consider the question of installing surface irrigation for potatoes in southern New Jersey. Accurate records of irrigation of that crop in the above-mentioned locality for 7 intermittent years out of 14 successive years, showed an increase due to irrigation of 40 bushels per acre per year. Assuming that no increase would have been obtained had irrigation been practiced during the other seven years, these results would indicate that a year-in, year-out increase of 20 bushels per acre could be expected to result from irrigation. These at \$1 per bushel (in the three years when the selling price was reported it was about \$1.50 per bushel) would indicate that an increased return of \$20 per acre per year could properly be credited to irrigation. Irrigation often justifies the application of larger amounts of fertilizer than can be economically used on unirrigated lands. Such increased applications may result in still further

returns, but let it be assumed that only \$20 per acre per year can be expected.

Under what conditions, then, can an irrigation system be installed and operated for a total cost of less than this \$20 per acre per year? Only under very favorable conditions could irrigation be provided on a 20-acre tract for less than \$20 per acre per year (including interest, taxes, depreciation, and upkeep and operation costs) if it were necessary to use pumped water. In southern New Jersey it should be possible to provide 40 acres of open-ditch irrigation on tracts with favorable slopes, where the total lift is not over 20 feet, for about \$16 per acre per year (including overhead and operation) where water is taken from an open pond or lake and the pump is driven by tractor. Under similar conditions it should be possible to provide irrigation for a 100-acre tract for somewhat less than \$13 per acre per year. On tracts of more than 100 acres a further reduction in annual cost would generally be possible with other conditions equally favorable. Increasing the lift from 20 to 30 feet probably would not increase the total annual cost more than \$1 per acre per year, provided the change did not put the power requirement above that of the power available in a tractor already at hand; and another 10-foot increase in lift might be made at the same additional cost, subject to the same provision. The above figures permit the use of no pipe other than suction pipe and a short discharge pipe. They therefore indicate that any water supply to be useful for potato irrigation must be near the field on which it is to be used and that irrigation under a lift of 20 feet is more profitable than that under a lift of 40 feet, although the cost of raising water to the latter height is not excessive for a large tract. A crop that would by irrigation be increased in value more than the \$20 above allowed, would, of course, justify a greater lift or more pipe; on the other hand a crop on the same tract with a less valuable increase would be profitable only under a smaller lift.

While the foregoing figures apply in particular to southern New Jersey, they are applicable to a large part of the eastern area where irrigation is practiced.

Records for seven consecutive years in southern Wisconsin indicated an average increase of onions, due to irrigation, of 131 bushels per acre. Records of tomato irrigation in the same locality showed an increase in yield of more than 4 tons per acre per year for the same period. On the other hand, four consecutive year's records in New Jersey showed an average increase of only one-half ton of tomatoes per acre per year. It should be noted with reference to the figures given that they are averages during a period that included wet as well as dry years. The increased quantity of tomatoes in New Jersey, for instance, was 2 tons per acre, and was all in one dry year; but as the record covers four years the average was one-half ton per acre per year. These figures indicate that in southern Wisconsin, at least, when the increased crop value is considered, an expensive system for the irrigation of onions may well be justified. For the irrigation of tomatoes an expensive outfit is also warranted if the crop can be placed on the market for direct consumption; but the increased profits to be expected from tomatoes for the cannery indicate that for them only moderate-priced equipment can be expected to be profitable.

The crop results set forth illustrate the well-known fact that some crops respond well to irrigation. But it must not be overlooked that both the increase in yield and the increase in value per acre resulting from irrigation vary considerably with the different crops and with the locality in which they are grown. Satisfactory figures of average irrigation increases of many crops are difficult to obtain. In general, the farmer who considers taking up the practice must judge for himself how valuable irrigation would be to him, and he must do this with little definite data to guide him. Careful investigation, however, would doubtless show some eastern farmers a chance to benefit by the use of surface irrigation.

INFORMATION NEEDED IN THE DESIGN OF A PLANT

The United States Department of Agriculture receives many letters asking for information regarding irrigation in the Eastern States. Before helpful advice can be given it is necessary to have the following information:

Acreage to be irrigated.

Kind of soil.

Source of water supply; estimated quantity available. (If a well, the size and type of well, distance to water, and probable draw down when pumped.)

Distance from water supply to land to be irrigated.

Difference in elevation between water supply and land to be irrigated.

Crops to be irrigated.

The general slopes of the land to be watered.

A sketch showing slopes of the land to be irrigated, location of the water supply, etc. It will be sufficient if this map indicates directions of slope by arrows and amount of slope in inches per 100 feet. An accurate topographic map is, however, very helpful and may be the means of a considerable saving.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

August 20, 1930

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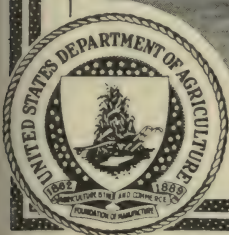
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FARM BULK STORAGE FOR SMALL GRAINS



U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF ENTOMOLOGY
WASHINGTON, D. C.

THE INCREASING USE of the combine harvester in many grain-producing areas, the present practice of paying premiums for wheat of high protein content, and the economic waste incident to the marketing of grain containing foreign material or dockage, has created a need for increased farm grain-storage facilities for wheat and other small grains. Faulty grain storages account for heavy losses due to the heating of grain in bins, to rodents, to excessive labor in handling, and to the rapid deterioration of structures. This bulletin explains the losses due to faulty construction, suggests better building methods, and presents designs for several types of storages for small grains adapted to wheat-belt conditions.

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FARM BULK STORAGE FOR SMALL GRAINS

By M. A. R. KELLEY, *Associate Agricultural Engineer, Division of Agricultural Engineering, Bureau of Public Roads*, and E. G. BOERNER, *Senior Marketing Specialist, Grain Division, Bureau of Agricultural Economics*

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INTRODUCTION

WHEAT generally ranks fourth in volume and also in value among all our farm crops and plays an important part in the commercial life of the Nation. A large proportion of the wheat crop each year is marketed from the farms within a few weeks after harvesting. The other small grains including rye, barley, flax, and grain sorghums are also marketed from the farm in large volume during the first weeks after harvesting. As a result the country elevators, the railroads, and, in turn, the terminal elevators are likely to be overtaxed. Orderly marketing would help to prevent market gluts and embargoes, which frequently result in lowered prices.¹

The farmer's granary is in a sense his bank, in which he may deposit the whole or a part of the grain resources of his farm; it provides a source of income to be drawn upon as required. The agricultural marketing act makes it possible in certain States and under certain conditions, to obtain a loan on wheat stored on the farm. The farmer is thus enabled to take advantage of what he considers to be favorable markets.

Farmers who are not equipped with storage facilities sometimes are compelled to pile their newly threshed grain on the ground, where often it is spoiled by rains. Large quantities of grain arrive at the terminal markets each year in a musty, sour, or heated condi-

¹ U. S. Dept. Agr. Leaflet 46, Farm Grain Storage.

tion. Damaged grain is graded according to the damage and frequently it is sold on the market at a heavy discount.

It is the purpose of this bulletin to aid the grain grower in planning proper storage for his grain in order to avoid losses due to grain damaged by improper storage, and to sell his grain to the best advantage.

FACTORS AFFECTING GRAIN IN STORAGE

MOISTURE CONTENT

The moisture content of wheat and other grains affects the grading and consequently the market value of the grain. The percentage of moisture present in newly threshed grain usually depends upon whether or not the grain was mature when it was harvested and threshed, the weather conditions during harvesting and threshing, and the extent and manner of exposure of the threshed grain to the weather. Small grains in the spring-wheat area, when in sound marketable condition, have a normal moisture content at time of threshing of from 11 to 14.5 per cent. In dry-land areas the normal moisture content of the grain usually is less than in the spring-wheat area. The United States grain standards (grades) specify that the maximum moisture content for grade No. 1 shall not exceed 14 per cent for spring and durum wheats and 13.5 per cent for all other wheats, 14.5 per cent for barley and oats, 14 per cent for grain sorghums, and 13 per cent for rye.²

Grain containing a moisture content in excess of these maximums is given a lower grading. Good, clean grain containing not more than the maximum amount of moisture permitted in grade No. 1 is considered to be sufficiently dry for safe storage. A lower moisture content is required for safe storage of grain that contains an appreciable quantity of broken kernels, weed seeds, or other dockage, because of the greater probability of its heating in the bins.

The climate in which wheat is grown affects somewhat the character of the kernel and in turn the storage requirements. Harvesting of wheat starts in the South early in June, and ends in the North near the Canadian border usually in September or October. The climate to which wheat is subjected varies in the different areas and as the harvest season advances. In some sections, particularly in the northeastern part of the hard winter-wheat area and in the spring-wheat area of the Great Plains, the nighttime rainfall and the relative humidity of the atmosphere from June to October (the months of harvest) usually is much greater than that in the daytime. The relative humidity at night is often as high as 90 per cent, and heavy dews are frequent. Wheat harvested during the day in such regions is subjected to lower night temperatures and to higher humidities than that harvested in regions of less varied temperature, and these factors affect the amount of moisture in the harvested grain and particularly that in the grain which is harvested during the forenoon hours of the day.

The areas having a dry summer climate produce dry grain requiring, so far as moisture in the grain is concerned, but cheap storage

² U. S. Dept. Agr. Handbook of Official Grain Standards. 1929.

on the farm, while the more humid sections usually produce grain of higher moisture content requiring greater care in handling and storage to prevent the grain from going out of condition.

Under normal conditions in the arid States of Arizona and Utah and in the inland portions of the Pacific Coast States the grain usually is mature and very dry at time of threshing. Such grain, owing to absorption of moisture from the air, increases in weight during storage in the rainy season following harvest and particularly after the grain has been moved to the seaboard markets. If the grain is not thoroughly air-dry at harvest there will be direct evaporation of moisture and a shrinkage in the total weight of the grain while it is in storage. In the more humid areas, if the threshed grain is either immature or contains excess moisture, evaporation of the excess moisture is necessary before the wheat can be safely stored. Grain stored in Ohio for five years showed a variation in weight of from plus 1 per cent to minus 2 per cent. Samples taken hourly from standing wheat in the fields of North Dakota in 1927 contained from 18 to 19 per cent of moisture early in the forenoon and, under weather conditions favorable for drying, 14 per cent in the late afternoon. After sundown the moisture content of the wheat increased rapidly and again reached 18 to 19 per cent during the night.³ The rate at which standing grain dries depends chiefly upon the humidity of the atmosphere, the temperature, and the velocity of the wind.

The moisture content of stored grain varies approximately with the humidity of the atmosphere, but this relation is affected to some extent by temperature. Changes in air humidity for short periods have very little effect on the weight of grain in storage. The change in weight of grain stored in large bulk is very slow, the rate of change depending upon the bulk and upon the amount of the air circulation through the grain. In a very large mass only the grain near the surface will be affected to an appreciable extent.

Stored grain may heat whenever its moisture content is more than is permitted for grade No. 1. Even grain of the maximum moisture content specified for grade No. 1 may not always be safe for storage. For instance, when it is stored under conditions which may cause condensation of moisture on the bin walls and roofs, or when the grain is subjected to the sun's heat, the grain may be damaged unless it is ventilated. Grain absorbs free water rapidly and under certain conditions readily takes up moisture from the atmosphere.

Condensation of moisture occurs when warm, humid air comes in contact with a surface the temperature of which is below the dew point⁴ of the surrounding air. Walls and roofs, when colder than the damp air within the storage bins, may act as condensing surfaces. The extent of condensation will vary with the rate at which heat is transmitted through the walls and roofs and with the rapidity and frequency of climatic variations.

When damp grain is put into storage, condensation occasionally is the cause of an increase in the moisture content of that part of the grain which is at the top surface of the mass and along the sides of metal and concrete bins. Condensation therefore is an important

³ U. S. Dept. Agr., Bur. Agr. Econ. Preventing Damage in Spring Wheat Harvested with Combine. June, 1928. [Mimeographed.]

⁴ The dew point is the temperature at which the moisture will begin to condense in the form of tiny droplets or dew.

factor in the design of storage structures. It is sometimes difficult to distinguish between the effects of leaks and those of condensation. Dampness in grain sometimes is attributed to leakage when condensation is the cause.

HARVESTING METHODS

New methods of harvesting and threshing have introduced new problems in grain storage. Where binding and shocking is practiced the grain-moisture hazard is in general less than it is where the grain is "combined" as is now the case in many areas. Any damp grain which is harvested with the binder, and any green weeds that are cut with the grain, have a chance to dry out in the shocks, and the weed seeds can more readily be separated from the grain during threshing.

When the combine is used direct, the grain should be dead ripe and dry at the time of harvesting and should stand in the field from a week to 10 days longer than when the binder is employed. A heavy growth of green weeds high enough to be cut by the combine results in a higher percentage of moisture in the mixture of grain and weed seeds than the grain itself contains. Weeds are more common in the spring-wheat than in the winter-wheat areas.

Green weed seeds found in "combined" grain may contain more than 60 per cent of moisture. When the grain in a mixture of grain and green weed seeds is dry it can be safely stored after the weed seeds have been removed. If it is stored without cleaning, the excess moisture in the weed seeds is readily transferred to the wheat kernels and fermentation is likely to occur. This condition in the spring-wheat area, where weeds are quite prevalent in the grainfields, has led to a common use in that area of the windrower, whereby the grain and weeds may be cut and dried in the swath.

The transfer of moisture from green weed seeds to drier grain kernels is quite rapid. It has been found, in the case of wheat held in a wagon box overnight, that by early morning much of the excess moisture in the weed seeds had been transferred to the wheat. Such grain should be cleaned before it is put in storage. In 1929 the average dockage in wheat threshed in North Dakota amounted to over 5 per cent, and during the same year the average dockage in the flax threshed in that State amounted to over 17 per cent. The production of weed-infested grain results in large loss since it adds to the cost of harvesting, threshing, and handling, and if the wheat is not cleaned before it is sold on the market its commercial grade and market value is lowered. Farm storage affords opportunity to clean the grain on the farm, and the screenings or dockage can often be profitably used for feed.⁵

HEAT DAMAGE

Excess of moisture at the time of storing is largely responsible for "out-of-condition" grain. Under favorable conditions of temperature and moisture, fermentation of stored grain occurs. As fermentation proceeds the temperature of the grain rises, resulting in sour, musty, and heat-damaged grain, which adversely affects its

⁵ U. S. Dept. Agr., Bur. Agr. Econ. Screenings as Feed for Livestock. May, 1924. [Multigraphed.]

germination and feeding values, as well as its milling or manufacturing qualities. Damp grain in storage therefore should be kept cool and well ventilated.

The loss due to "out-of-condition" wheat and other grains is large. The difference in price between sound and heat-damaged grain usually ranges from 5 to 15 cents or more per bushel depending upon the extent of the damage. It is always a safe practice to examine the grain frequently and at the first indication of heating to aerate the grain by transferring it to another bin, repeating the process as often as may be necessary to reduce the temperature and to stop fermentation. Although this can readily be done in the local country elevators it is not easy to do on the farm unless extra storage space and grain-handling machinery is available. The farm storage should be so designed as to enable the farmer to change heating wheat from one bin to another quickly and with little labor. This involves the installation of elevating equipment, which is now available on the market for use in farm storage.

REDUCING MOISTURE CONTENT

The moisture content of damp grain may be lowered by any one or by a combination of several methods, such as delaying the harvest until the grain is dry, mixing the damp grain with dry grain, using ventilated bins or artificial driers, and by employing construction materials that prevent the rapid passage of heat through the bin walls.

It is highly desirable that combining and threshing be delayed until the grain is dry enough to be safely stored. However, weather conditions during the harvesting and threshing period are at times such that it is difficult to avoid damp threshed grain. Damp threshed grain must be dried in some manner if spoiling in storage is to be avoided. When the grain contains only a slight excess of moisture it can be dried on the farm by placing properly constructed ventilators in the bins (p. 24), by mixing small quantities of the damp grain with other grain of the same kind which is thoroughly dry, or by frequently moving it from one bin to another on warm dry days. To employ either of the two last-mentioned methods requires grain-handling machinery for practical results. To mix damp grain with dry grain is practical only when the moisture content of the dry and the damp grain is such that the moisture content of the mixed grain will be sufficiently low for safe storage.

When the newly threshed grain is of a high moisture content it is a common practice to deliver it immediately to a local elevator or to ship it to a terminal market, where it may be kept in good condition by being dried, mixed with dry grain, or frequently moved from bin to bin. However, during periods of heavy deliveries from the farms the local elevators often have difficulty in successfully handling large quantities of damp and wet grain, with the result that such grain frequently takes a heavy discount in price and often will not be accepted at the elevator at all.

Some country elevators are equipped with artificial driers in which the moisture content of damp grain may be reduced to a point for safe storage.⁶

Driers of suitable capacity for farm use may be had, but at the present time the high initial cost prohibits their general employment on farms.

PLANNING GRAIN STORAGE

The farm storage may consist of an elevator, a granary, portable bins, or emergency bins. Before the building is started, decision should be made as to whether the shelter is to be temporary—providing for only immediate needs—or one that is substantial, permanent, and capable of expansion as future needs may require.

It is unwise to attempt to erect any substantial building, particularly large grain storages, without carefully prepared plans. Unless each feature of the construction, arrangement, and equipment is studied and its relation to other features definitely determined before erection is started, costly mistakes may be made. Errors in design are easily corrected, on paper. Changes in the completed or partly finished structure may prove very expensive.

Lack of knowledge of the strength of materials on the part of the builder, poor judgment in the selection of the site, and poor workmanship have caused many failures of grain storages. It is inadvisable to trust inexperienced builders with such construction. The errors most commonly found are faulty foundations and insufficient bracing and tying. Overloading also is a frequent cause of failures. Farmers, in building new structures, frequently copy existing buildings in their locality. Many good ideas may be obtained from one's neighbors, but to follow too closely is often a mistake, as conditions and requirements vary. The farm granary should be so designed as to meet the requirements of the particular farm. No one type of granary is suitable for all conditions of grain farming.

The granary should be located conveniently with respect to the movement of trucks or wagons to and from the fields. The site should be well drained and in such relation to other buildings as not to mar the appearance of the farmstead. If the granary is to be used in connection with cattle or stock feeding, careful planning will save much labor and time in caring for the stock.

SPACE REQUIREMENTS

The size of the granary is determined by the average quantity of grain to be stored each year. It is desirable to provide a number of bins of convenient size to permit the separation of the wheat into different grades and varieties, the old from the new, and the damp from the dry. It also permits of shifting grain from one bin to another to prevent heating. For this purpose a small extra bin should be provided, or the larger bins should be but partly filled. The bins may be numbered for convenience in keeping records.

A standard bushel of wheat occupies approximately $1\frac{1}{4}$ cubic feet of space and weighs approximately 50 pounds per cubic foot. The capacity of a bin, in terms of bushels, may easily be calculated by

⁶ U. S. Dept. Agr. Circ. 127. Grain Drying at a Country Elevator.

multiplying its volume (length by breadth by depth) by 8 and dividing by 10.

In addition to grain-storage space, provision should be made, in permanent storages, for space and equipment needed to facilitate handling the grain in conditioning, cleaning, grading, treating, and grinding. The space and equipment will vary with the individual needs.

STRUCTURAL REQUIREMENTS

MATERIALS

The essentials of a successful grain storage are sufficient structural strength and dryness. The selection of materials of construction and the manner in which they are assembled are of great importance. The materials commonly used in the superstructure are wood, concrete, hollow tile, and galvanized metal, the last being commonly used in dry-land areas. No one material may be considered superior for use under all the conditions. Some farmers may wish to convert an existing building, some may emphasize the desirability of fire-proofing, some may want to build in harmony with existing structures, and others may wish to employ certain readily available materials.

FOUNDATIONS

The foundations of grain storages must support a greater weight than do those of most farm buildings. Hence, they should be constructed of materials that will not crush, made wide enough at the bottom to carry the load without settling, and extend far enough below the surface of the ground to prevent heaving by frost. It never is advisable to place footings on top of the ground; rats easily burrow under them, as shown in Figures 1 and 2, and rains may wash the soil from beneath them (figs. 3 and 4), permitting the building to settle. Standing water in hog wallows or pools formed by drip from eaves may soften the soil under a portion of the foundation and cause unequal settlement.

The materials commonly used in the construction of foundations are concrete, stone, brick, hollow tile, and concrete blocks. A well-constructed foundation (fig. 5) insures uniform distribution of the weight of the building and contents on the soil, prevents unequal settlement and racking of walls, reduces repair bills, and prolongs the life of the granary.

Concrete foundation walls can not well be made less than 8 inches thick because of the characteristics of tools generally available for trench digging and the difficulty in properly placing concrete in forms of less width. For stability, brick walls must be made at least 8 inches thick. Stone walls should generally be 16 inches thick in order to obtain thorough bonding of the material, but if the stones are of suitable shape and care is taken in laying them they may be made 12 inches thick. Hollow tile and concrete blocks are not generally suitable for foundations carrying heavy loads. They may be used in foundations supporting light loads provided the material is sound and hard and the workmanship first class.

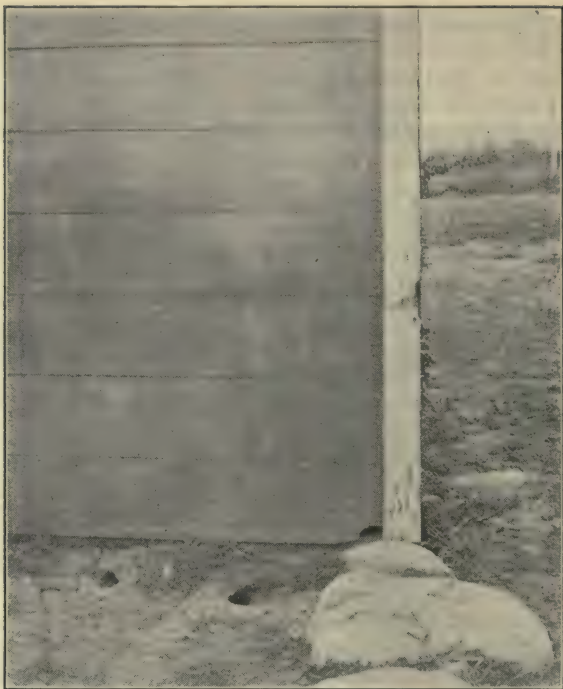


FIGURE 1.—Corner of a granary with poor foundation of insufficient depth to prevent easy entrance of rats



FIGURE 2.—A small granary set on a poor foundation and so close to the ground as to cause early rotting of sills and joists through dampness and to provide excellent harborage for rats



FIGURE 3.—A small granary of approximately 1,000 bushels capacity. The floor is raised sufficiently, but the footings are practically on top of the ground, affording no protection against frost action and soil washing. Design No. 2392 (p. 44) provides for a proper storage of similar type and capacity. Estimated cost, \$500



FIGURE 4.—A foundation made insecure by the washing away of the soil underneath

The strength of any masonry work depends upon the quality of the material and the workmanship. Farmers' Bulletins 1279, Plain Concrete for Farm Use, and 1480, Small Concrete Construction on the Farm, contain information pertaining to the mixing and placing of concrete. Only hard-burned bricks should be used in brick masonry. Stone should be selected for hardness and flat bearing surfaces. All masonry should be laid in mortar of strength not less than that consisting of 1 part Portland cement and 3 parts sand. The addition of 9 pounds of hydrated lime for each bag of cement will make the mortar more plastic and easier to handle.

Continuous 8-inch concrete or brick walls and 12 or 16 inch stone walls, when not over 6 feet high, will carry any load likely to be



FIGURE 5.—An excellent farm granary, 30 by 32 feet, of 7,000 bushels capacity set on good 10-inch concrete walls with 16-inch footings. The sills are 18 inches above grade, allowing good air circulation, which is conducive to long life of timbers, and affording no harborage for rats. The building is well braced and tied together. It is filled by means of a portable elevator

placed upon them in farm-granary construction. Footings may not be necessary on some soils, but it is generally advisable to provide them in order to resist overturning of the wall and to provide against inequalities in the soil. Figure 6 illustrates failure due to insufficient footing.

The smaller granaries often may be more cheaply supported on piers and wooden girders. Concrete, brick, or stone piers 10, 12, and 16 inches square, respectively, if not more than 8 feet apart will safely support the loads incident to small-granary construction, but the soil beneath may not do so. In that case larger piers or footings must be employed to distribute the load on the soil. The footing must not be so thin as to crack under the load.

The bearing power of soil varies with its character and condition. For general use the following loads, in tons per square foot, may be considered safe on the kinds of soil specified: Dry clay, 4 to 6; moderately dry clay, 2 to 4; soft clay, 1 to 2; compacted gravel and coarse sand, 8 to 10; clean dry sand, 2 to 4; quicksand and alluvial soils one-half to 1.

The dimensions of a footing for a continuous foundation wall with a uniformly distributed load are roughly determined by dividing the total load, in tons, on the wall by the length of the wall in feet, the result being the load on each lineal foot of soil beneath the wall. The footing must project on each side of the wall to provide a bearing surface large enough on the basis of the safe loads given above, to support the load on each lineal foot of wall. The width of the footing having been determined, the thickness (height) should be made equal to the difference between the width

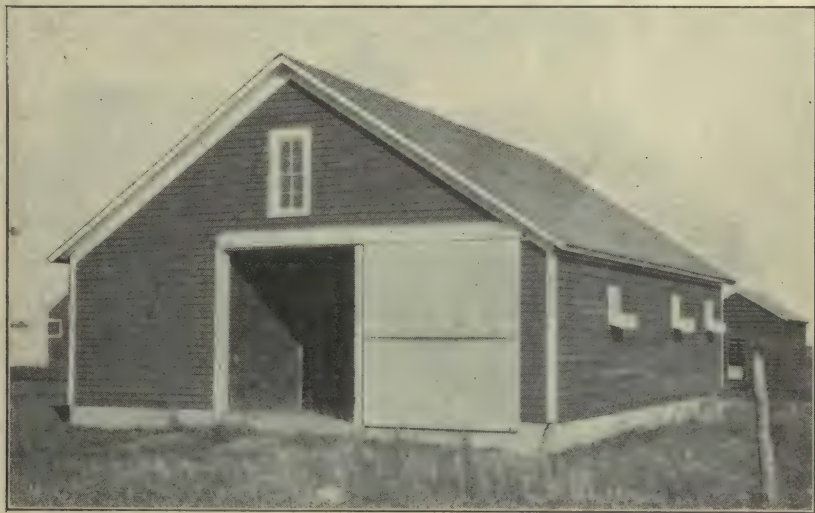


FIGURE 6.—A common type of multibin granary with a driveway through the center. Note failure of foundation at the right-hand corner, due to a footing too small for the bearing power of the soil

of the footing and the thickness of the wall. The foundation must be centered on the footing.

The dimensions of a pier footing may be determined in much the same manner. The area of the footing must be such that the load per square foot is less than the bearing power of the soil. The projection must be the same on all sides of the pier. Where the bearing power of the soil is low, wide footings may be necessary, particularly under piers. If, by reason of the width, the height of the footing is greater than 18 inches it may be stepped or beveled, thus saving concrete. Large granaries or elevators built on soil of low bearing power may require very wide footings, in which case it may be more economical to use steel reinforcement. Such structures may, on some soils, settle as much as 12 inches when filled, but no damage will occur if the settlement is uniform. Because of the many factors involved, foundations for such storages should be especially designed by competent engineers or builders.

Large field stones or boulders sometimes are used as piers and at times in continuous foundations. If they are not well chosen and placed, the result is unequal settlement of the building as shown in Figure 7. Such stones should be carefully selected for uniformity of size of flat bearing surfaces and should be set deep enough in the ground to avoid the effect of frost action.

The height of the foundation above the ground should be such that the sills and floor joists shall be supported a foot or more above the ground and the sills should be set in mortar so as to insure even bearing. If the building is set too close to the ground, as is the case in Figures 1 and 2, there is little chance for air circulation under the sills and joists, which will deteriorate rapidly. If the structure is set well off the ground, as shown in Figures 3, 5, and 7, the life of all base timbers is increased, and there are no dark, in-

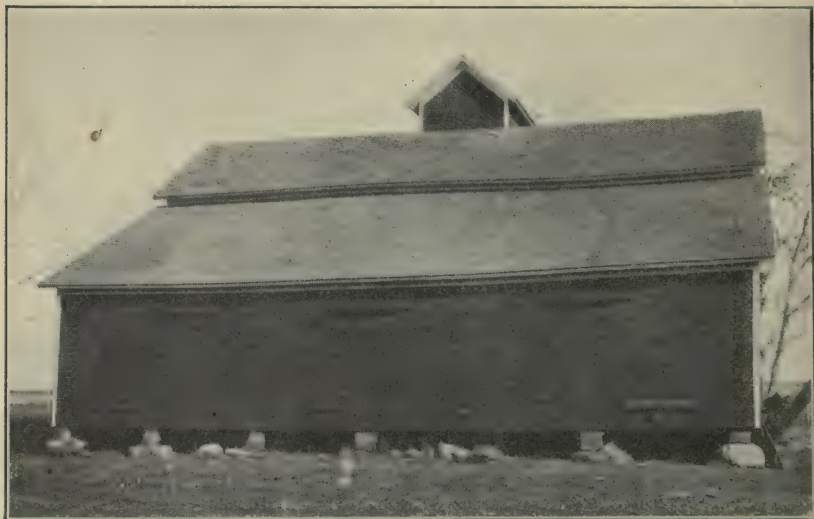


FIGURE 7.—Inadequate foundations cause settlement and racking of building

accessible places to harbor rats. If the foundation is a continuous wall completely inclosing the space under the granary, vent openings screened against rats should be provided to permit the circulation of air necessary to prevent the rotting of timbers. Such foundations make for the better appearance of the building, but two or more parallel bearing walls without end cross walls are cheaper and permit of better air circulation under the building as well as access for cats and dogs. (Fig. 5.)

FRAMING

Two general styles of framing—balloon and crib—are used in grain storages on the farm. The balloon type is most commonly used for structures under 8,000 bushels in capacity. In this type the walls consist of sheathed studs 12, 16, or 24 inches center to center. Examples of this type are shown in Figures 5, 7, and 8.

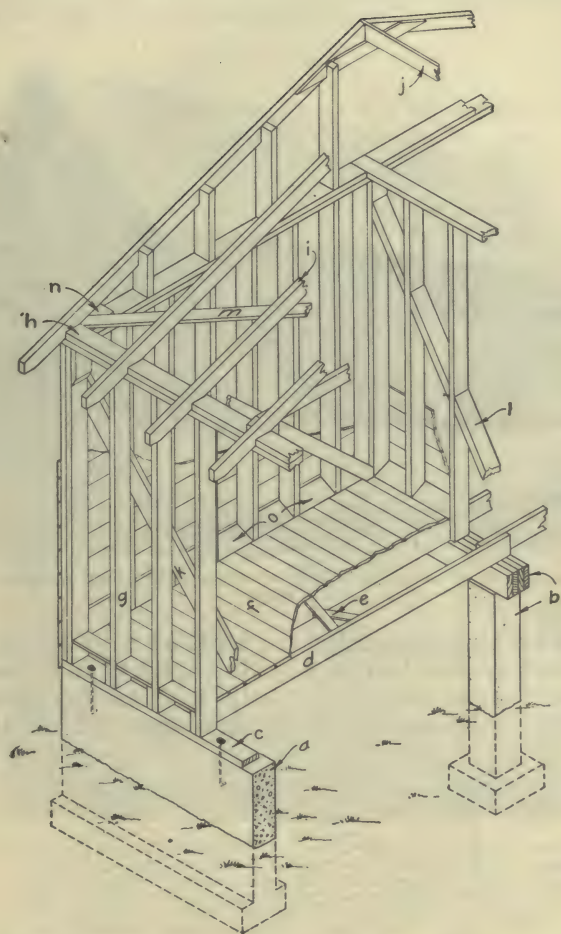


FIGURE 8. Framing of granary of balloon-type construction: *a*, Continuous-wall foundation; *b*, pier and girder construction; *c*, sill; *d*, joist; *e*, bridging; *f*, floor; *g*, stud; *h*, double plate; *i*, rafter; *j*, ridge pole; *k*, brace spiked to inside of the studs; *l*, brace cut between the studs; *m*, brace spiked to the under side of rafters; *n*, wedge block under end of rafter brace; *o*, beveled boards between studs

In the crib type (figs. 9 and 10) the walls are built up of 2-inch lumber laid flat and spiked together, the width being determined by the height of the structure. For buildings 24 feet or less in height, 2 by 4 inch lumber is used. In walls 24 to 40 feet high



FIGURE 9.—Granary of the crib type, built on a bank side, with walls of 2 by 4 inch lumber

the lower 16 or 18 feet usually are built of 2 by 6 inch material; in walls of still greater height 2 by 8 or 2 by 10 inch lumber is employed in the lowest part of the walls with smaller timbers above. The crib type of framing is preferable when the storage capacity

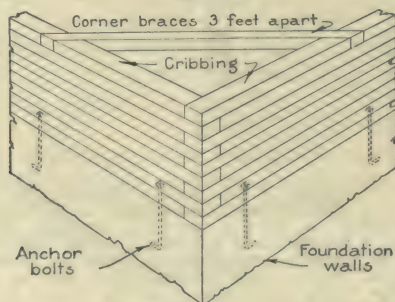


FIGURE 10.—Method of constructing crib walls.

exceeds 10,000 bushels. Figure 11 shows a metal-clad farm elevator of the crib type. This structure cost no more than a balloon-type building of the same capacity would have cost.

The strength of timber varies with the kind and grade. The cost of timber varies with kind and locality. The most common commercial timbers are oak, yellow pine, fir, spruce, white pine, hemlock, and cottonwood, named in the order of their relative strength. Large defects, particularly knots, greatly weaken timbers, but it is sometimes possible to sort them and to use the best timbers in those positions requiring greatest strength.

STUDS

Balloon construction is not recommended for heights much greater than 24 feet. Only seasoned lumber should be used. Figure 12 illustrates a failure in this type of construction. The studs in this



FIGURE 11.—Farm elevator of the crib type. The metal covering gives protection against entrance of rain, saves painting and affords some protection against fire from the outside. The peculiar roof construction is due to the arrangement of the elevating machinery. A stairway provides easy access to the elevator boot

elevator are 2 by 6 inches, spaced 12 inches center to center, and 40 feet high. The bins can not be filled to full capacity without danger of complete failure. Balloon structures of this height must be thoroughly braced and tied, which adds materially to the cost.

Table 1 gives size and spacing of studs which have been found satisfactory in common practice for single-boarded bins not over 12 feet deep. Since defects have a greater relative effect on the strength of 2 by 4 inch studs than on that of larger sizes, the 2 by 4 inch material should be selected with care.

TABLE 1.—Size and spacing of studs for farm grain bins of various depths

Depth of bin	Size of studs	Spacing of studs center to center	Depth of bin	Size of studs	Spacing of studs center to center
<i>Feet</i>	<i>Inches</i>	<i>Inches</i>	<i>Feet</i>	<i>Inches</i>	<i>Inches</i>
5	2 by 4	24	8	2 by 6	24
8	2 by 4	16	10	2 by 6	16
9	2 by 4	12	12	2 by 6	12



FIGURE 12.—Failure of an overloaded grain elevator of the balloon type of framing, 40 feet high with studs spaced 12 inches center to center. In addition to the failure of support at the driveway the walls have bulged

BRACES AND TIES

Particular attention must be given to the providing of braces and crossties in order to prevent overstraining and bulging of studs. Their omission is a common fault in storage structures, and as a consequence many buildings are found in the condition shown in Figures



FIGURE 13.—Lack of proper bracing—a too common fault—results in distortion of the building. A high foundation increases the life of sills and joints. Rodents can not climb metal-covered posts



FIGURE 14. Portable bins of 600 bushels capacity with no bracing to prevent racking by wind or strain in moving. Bulging of the studs was due to an insufficient number of ties. The bins are filled directly from the thresher

13 and 14. Such failures may be avoided by the use of a few braces well spiked to the side of the studs or cut in between them. Braces let into the studs weaken them and may lead to early failure of granary walls. The wall bracing in Figure 8 illustrates two of the most common methods of strengthening and stiffening stud walls. The brace *k* is spiked to the inside of the studs; brace *l* consists of short pieces cut in between the studs. Brace *k* should be of nominally 1-inch material, as wide or wider than the studs, and must be well nailed especially at the ends. Brace *l* should be of the same dimensions as the studs; to be efficient the joints must be well made and thoroughly spiked. Brace *k* is the more efficient. Brace *m*, extending from the junction of the end and side walls with the roof to the ridgepole, is spiked to the underside of the rafters. With such



FIGURE 15.—A farm elevator of the balloon type of 7,500 bushels capacity. The building, including stay timbers for the tie rods, is metal-clad

a brace at each corner any tendency of the roof to sag is overcome. Bracing of the roof rafters is particularly desirable in the larger structures.

Wire ties sometimes are used in small structures. In the larger structures $\frac{5}{8}$ to $\frac{3}{4}$ inch rods are spaced $3\frac{1}{2}$ to 4 feet apart. (Figs. 12 and 15.) Where the height of the walls is from 6 to 10 feet one or more ties, depending upon the length of the wall, usually is sufficient. In walls of greater height, two or more sets of ties are required. (Figs. 7 and 15.)

Figure 16 shows the failure of a farm granary, 12 by 32 by 10 feet after but a few months of use. The studs are 2 by 6 inches and are spaced 24 inches center to center. The wire ties, too few in

number and placed too high, proved inadequate, with the results as shown. The greatest outward thrust appeared to be on the lower 4 feet of the wall. Since ties at this level would interfere with the headroom, the studs should have been larger or more closely spaced. Ties should be used wherever the depth of stored grain is over 6 feet. In shallow bins the ties may be placed 6 feet from the floor, but in bins more than 10 feet deep lower ties are necessary. The stay timbers, to which the ties are secured, often are spiked to the outside of the studs. Unless they are protected by flashing, as shown in Figure



FIGURE 16.—Failure of a new granary due to overloading and inadequate tying and nailing

17, A and B, water gets behind them and causes rotting of both sheathing and timber. Sometimes they are fastened on the inside of the studs by means of wagon-box strap bolts (D). The use of U or hook bolts is shown in E. In placing these bolts the studs should not be notched as this weakens them. The tie rods extend through the stay timbers (E), or they may be secured to studs with fastenings similar to hay-track ridgepole brackets as shown in D. The first method is preferable as it provides the better anchorage, and turnbuckles are not necessary. The latter method is better adapted to installation in bins already erected.

JOISTS

The size of joists required varies with the span and the depth of grain. In the deeper bins the arching action of the wheat tends to put part of the load on the walls, decreasing the load on the joists. The clear span of the joists should not be more than 10 feet. Driveways should not be more than 10 feet in width if bins are to be erected above them. Cross grain or twisted joists, or joists with long end splits, should not be used. Knots on or near the lower edge of a joist have a weakening effect and should not be permitted if the average diameter is more than one-eighth of the height of the joist. Knots on the top of joists are much less objectionable, and knots in the center of the height have little influence on the strength of the timber.

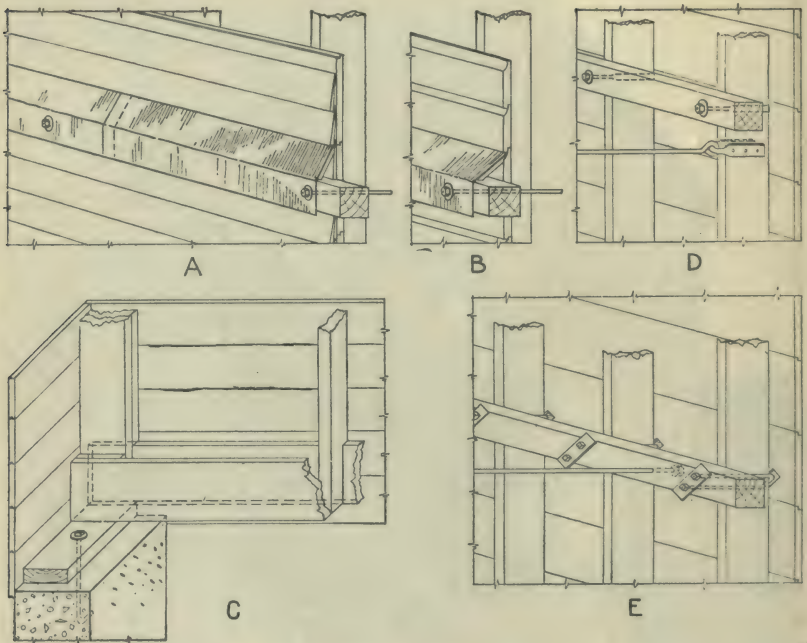


FIGURE 17.—Bin-wall details: A, Exterior stay timber with flashing on double-boarded wall; B, flashing with single boarding; C, framing of studs, joists, and sill at corner of a granary; D, stay timber secured with wagon-box bolts, the tie rods being secured to studs; E, inside stay timber secured to studs with U bolts, the tie rods extending through the timber

As a rule, much greater strength for a given amount of material can be obtained by increasing the height of a joist rather than the width. However, the height preferably should be limited to not more than six times the thickness and not more than one-tenth of the length of the span.

The joists should be bridged to prevent twisting and turning under the load. The ends of the joists should be spiked to the studding and to plates or sills of ample bearing surface. Good construction is shown in Figure 8. Proper framing at the corner of a granary is

shown in Figure 17, C. Where piers are used the heavy sill should be securely bolted to each pier. The joists should be not more than 24 inches on centers, and usually not less than 12 inches, depending on the size of joists and the load to be supported.

Table 2 gives suggested sizes, spans, and safe loads for joists supporting different depths of wheat in the bin. These figures must be considered only as a guide intended to lessen the liability to failure. The knowledge and experience of the builder with respect to the kind and quality of the lumber used may make departure from these values desirable.

TABLE 2.—*Safe, uniformly distributed loads for joists*

Size, inches	Safe load for a ¹ —				
	6-foot span	7-foot span	8-foot span	9-foot span	10-foot span
	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>
2 by 6.....	1, 150 to 1, 700	1, 000 to 1, 450	900 to 1, 300	1, 300 to 2, 000	1, 900 to 2, 900
2 by 8.....		1, 750 to 2, 600	1, 550 to 2, 300	2, 150 to 3, 250	2, 900 to 4, 300
2 by 10.....		2, 800 to 4, 200	2, 400 to 3, 600		
2 by 12.....			3, 600 to 5, 400		

¹ The higher values for each span apply to the stronger woods such as oak, yellow pine, and fir of good grade; the lower values to woods of less strength.

FLOORS

All floors should be tight and smooth. Tightness is particularly necessary where the grain is to be fumigated; in such cases the floors should consist of two layers of tongue-and-groove flooring with paper between them in order to prevent the escape of the gas. Wood floors should be constructed of well-seasoned, dressed, and matched flooring to avoid cracks due to shrinkage. The low foundation shown in Figure 2 does not permit air circulation whereas the construction shown in Figure 5 protects timbers from dampness. Although the building shown in Figure 13 has been in service for more than 50 years the joists and sills are still in good condition.

A concrete floor should be smooth with all joints between walls and floor made water-tight. Directions for laying concrete floors, are given in Farmers' Bulletin 1572, Making Cellars Dry. All concrete floors should be waterproofed (p. 22).

SHEATHING

The studs of granary walls may be sheathed on the inside or the outside, or both. If they are sheathed on the inside, ship-lap or matched lumber should be used. This is generally done in temporary structures, the studs and sills being exposed to the weather. Novelty or drop siding may be used on the outside. Ship-lap also may be used on the outside, but in some regions it should be covered with beveled or drop siding as protection from the weather. Inside boarding of permanent bins within a building facilitates cleaning, but it reduces the capacity of the bin and provides inaccessible spaces where

rats may harbor. The construction shown in Figure 18 makes for ready cleaning at much less expense and does not lessen the capacity.

Plain, square-edged boards sometimes are used for sheathing, but this is not advisable since shrinkage cracks between the boards are sure to occur and grain will be lost. Moreover, plain boards do not provide sufficient protection against wind-driven rains. For these reasons in the spring-wheat area the walls often are double-boarded, sometimes with building paper between the layers. The walls should be so constructed wherever fumigation of the grain is likely to become necessary.

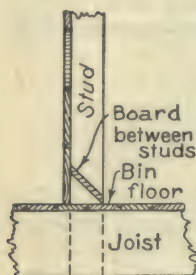


FIGURE 18.—Bevel-edged boards cut between the studs facilitate the cleaning of bins

The sheathing boards should be well nailed. Two tenpenny wire nails at each stud should be used in outside boarding of deep bins where they must resist considerable grain pressure. The strength and stiffness of a horizontally sheathed wall in which two tenpenny nails are used at each stud is about 40 per cent greater than when two eightpenny nails are used. Two eightpenny nails are sufficient to hold inside boarding in place. A failure partly due to inadequate nailing is shown in Figure 16. Figure 11 shows a farm elevator sheathed with metal to protect the woodwork.

The nails used to secure the metal were too small. Failure was due to shrinkage of the wood and expansion of the metal which pulled the nails over a large area, allowing one section of the metal covering to drop. The use of larger nails—either barbed or coated—would have prevented this.

WATERPROOFING

If the walls are of concrete, brick, or building blocks, especial attention must be given to making them absolutely water-tight. Entrance of water through cracks or mortar joints, or through the wall material itself, must be prevented. One method of doing this is to apply waterproofing paint of proved value to the inside and outside surfaces, as was done on the structure shown in Figure 19.

Walls of solid concrete, brick, or hollow building block 8 inches thick should be satisfactory in moderately warm, dry climates, provided they are kept dry by a protective coating. In regions subject to extremes of temperature and humidity, insulation in addition to waterproofing may be necessary, especially for the safe storage of grain that is not thoroughly dry. However, leaking walls often are the result of poor workmanship. If the materials are of good quality and properly placed further protection may not be necessary. On a well-drained site a dry concrete floor may be obtained by leveling the ground and laying the concrete on top of a well-compacted layer of gravel, crushed stone, or cinders 6 or 8 inches deep; but positive assurance of a dry floor may be had only by placing a layer of waterproof material under the concrete. Methods of waterproofing concrete floors and walls are described in Farmers' Bulletin 1572, Making Cellars Dry.

The joints in metal bins sometimes leak, but more often moisture found on the inside is due to condensation. Asphalt paint often is

applied to metal bins to prevent leakage and to protect the metal. (Fig. 20.) This should not be done unless a coat of white paint is applied over it, as black paint tends to raise the inside temperature.

INSULATION

Condensation of moisture within the bin, often the cause of spoiled grain, will not occur if the grain is thoroughly dry or if the temperature of the inside surfaces of the walls and roof is kept above the dew point (footnote 4, p. 3) of the air within the bin. This may be accomplished to a certain extent by the use of insulation, that is,

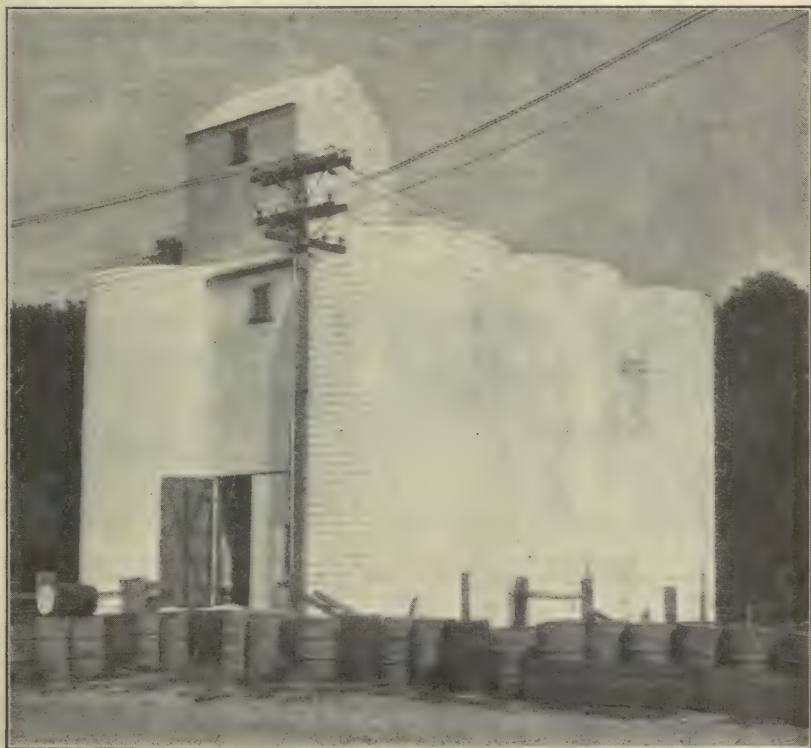


FIGURE 19.—A new farm granary built of concrete blocks which have been painted with a waterproofing paint

such construction as will prevent too rapid lowering of the inside temperature next to the bin walls and roofs. As warm, moist air rises to the top of the bin, the insulating of roofs is of greater importance than that of side walls. If, however, the temperature of the inside surfaces approaches the dew point of the air within the bin more rapidly than the dew point can be lowered by the removal of moisture by ventilation, condensation will result.

In regions of low humidities and high temperatures, insulation as a means of preventing condensation is of less importance than in those regions where climatic conditions are more conducive to condensation. Because of lack of definite information with respect to

the temperatures occurring in grain bins in different localities it is not possible to state the amount of insulation required. Observations made of a large number of frame structures indicate that as dry wood is relatively a good insulator no special precautions with respect to condensation are required for wooden bins.

Metals conduct heat much more readily than do nonmetallic substances. For this reason metal grain bins, particularly the roofs should be insulated to protect the grain from overheating caused by the sun's rays and from condensation due to marked changes in temperature. Thoroughly dry grain is not affected by the sun's heat.

VENTILATION

Damp grain should be kept cool and well ventilated. If the farm storage is equipped with elevating machinery, damp grain often can be dried sufficiently by frequently transferring the grain from one bin to another during warm, dry weather. If the grain contains



FIGURE 20.—Metal bins made from an old silo. They were covered with asphalt paint to waterproof the joints, but this coating adds to the absorption of the sun's heat

only a slight excess of moisture, it can be dried in bins equipped with ventilating ducts open at each end to outside air, such as shown in Figure 21. The provision of a ventilator and ventilating ducts does not alone constitute good ventilation for they must be properly operated. The ducts should be provided with doors which may be closed readily at night or whenever the weather conditions are not favorable for ventilation, as on a damp day following cool weather when the introduction of damp air into a mass of grain of lower temperature would cause condensation and increase rather than decrease the moisture content of the grain. In a test in North Dakota, wheat having a moisture content of from 16 to 18 per cent was successfully stored in such bins after it had been cleaned.

The condition of the circulated air affects the drying process. Natural drying is accomplished by introducing into the bin outside air of proper condition. During the early period of storage the air within the bin is likely to be of comparatively high humidity owing to the respiration of the grain. If outside air of the same temperature but of lower humidity is introduced and circulated through

the bin it will absorb moisture from the inside air and the grain. If the outside air is of lower temperature and of even higher humidity than the air within the bin, the effect is the same since the outside air is warmed and its capacity for holding moisture is increased.

Newly threshed grain having an excess of moisture respires freely and throws off heat and moisture, particularly during the early part of the storage period. It is therefore necessary to provide for circulation of air over the top of the mass. In storages having open-top bins this circulation may be provided by opening the windows. Separate portable or permanent bins with roofs should be provided with air inlets in the side walls and a central outlet in the roof. All openings should be constructed so as to prevent entrance of snow or rain.

RAT PROOFING

Rats and mice are responsible for heavy losses in stored grain. If rodents are furnished good harborage near a supply of food, they increase rapidly in number. The remedy is to destroy as many of the rats and their burrows as possible and to make all storage structures rat proof.

Rats seek shelter in dark places beneath buildings and in rubbish piles where their runways will be unmolested by natural enemies. If the floor of the granary is a foot or more above the ground, rats are less likely to burrow under the building, and dogs and cats can get at them readily. If the building is set close to the ground rats, in burrowing, will pile up mounds of moist earth against the floor joists and sills, often causing early rotting of these timbers.

Metal bands 8 to 10 inches wide are sometimes nailed to the sides of the building, forming a belt beyond which the rats are unable to climb. Figure 22 shows ineffective use of metal stripping as a rat barrier. Metal strips sometimes are nailed around the top of the supporting posts of the granary as shown in Figure 13. If the foundation is built of loosely laid stone as in Figure 23, it is impossible to keep rats out and once they are in it is very difficult to dislodge them.

Trapping and poisoning are effective measures in the eradication of rats.⁷ Poisons, however, because of their danger to human beings and to farm animals, must be employed cautiously. Recent experiments by the Bureau of Biological Survey show that red squill

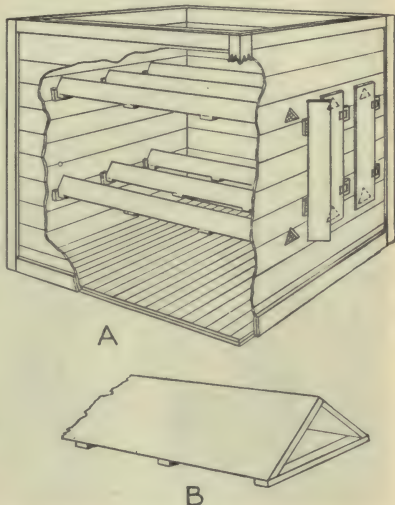


FIGURE 21.—Ventilated grain bin: A.—View of ventilators in position in the bin. These are placed 20 inches apart in tiers which are also 20 inches apart, one above the other. Screened openings in the bin walls at the ends of each ventilator are fitted with doors, which when closed prevent circulation of air. B.—Construction of ventilators

⁷ U. S. Dept. Agr. Farmers' Bul. 1533, Rat Control.



FIGURE 22.—A misdirected effort in rat proofing. The metal band at the junction of floor and wall of a bin failed to exclude rats as they gained entrance through the door and by climbing the studs



FIGURE 23.—A foundation of loose stones permitting entrance of rodents and affording excellent protection against their natural enemies

is an efficient and economical poison. Since it has been fed to cats, dogs, poultry, and pigs without apparent ill effects, its use in baits is to be recommended in preference to the more active poisons.

HANDLING GRAIN FOR STORAGE

Methods of handling grain have changed with improvements in harvesting machinery and equipment. The binder and separator, with wagon transportation and hand labor, are now being replaced quite generally in many areas by the combine, supplemented by the truck and the power elevator. Scooping grain into the bin, as shown in Figure 24, was all right in the days of small acreage and cheap labor, but to-day it is wasteful of man power. The combine



FIGURE 24.—The old hand method of handling grain, adequate for small crops but wasteful of man-labor and expensive in handling large quantities of grain. Note the convenient height of grain doors

has so speeded up the cutting and threshing that hand methods of transferring grain from wagon or truck into storage bins retard the harvest unless extra labor is employed.

The handling of grain in sacks from the thresher or combine to the market is a practice that is rapidly being abandoned. Little human effort is required to move grain in bulk, whereas sacks must be sewed, lifted, and piled to be again lifted and loaded on to trucks or wagons. When grain is handled in bulk, advantage may be taken of the fact that it flows readily. Practically no man power is then required to move it at a speed impossible to attain with the bag system. Additional information on the economy and ease of bulk handling of grain is given in Farmers' Bulletin 1290, *The Bulk Handling of Grain*.

Grain should never be stored in old bins until they have been thoroughly cleaned. This is especially important when the previous crop was infested with weevils or disease. Dust and old grain left in corners and cracks usually are infested with weevils which attack the new crop.⁸ If short pieces of boards are cut between the studs, as shown in Figure 18, the bins may be more easily swept clean.

POWER ELEVATING MACHINERY

Grain-elevating machinery of varied design is now available for farm use. There are two principal types, portable and stationary.



FIGURE 25.—A portable elevator used for filling a granary through a gable window

A portable elevator (figs. 25 and 26) consists of three principal parts, namely, the wagon jack or dump, the receiving hopper, and the elevator leg. It may be driven either by horse or by belt power. These elevators usually are light and strong and generally are mounted on wheels so that they may be readily moved about the farm.

⁸ U. S. Dept. Agr. Farmers' Bul. 1483, Control of Insect Pests in Stored Grain.

An overhead dump consists of a steel or wooden frame (fig. 25) equipped with a windlass, cables, and pulleys. The cables are attached to the hubs of the front wheels of the wagon, power is applied to the windlass, and the front end of the wagon is raised to the desired height.

The receiving hopper usually is attached to the elevator leg and generally is so arranged that it may be either raised (fig. 26) or swung to one side so that the load of grain may be driven into position for dumping. The portable elevators illustrated can not be operated efficiently with the leg at an angle much greater than 45° because of the small quantity of grain that can be kept ahead of the cross bars as they move up the trough. The capacity of these elevators under normal conditions of operation is approximately 500 bushels per hour.

By means of the portable elevator grain easily may be put into any bin of moderate height including overhead bins in barns and

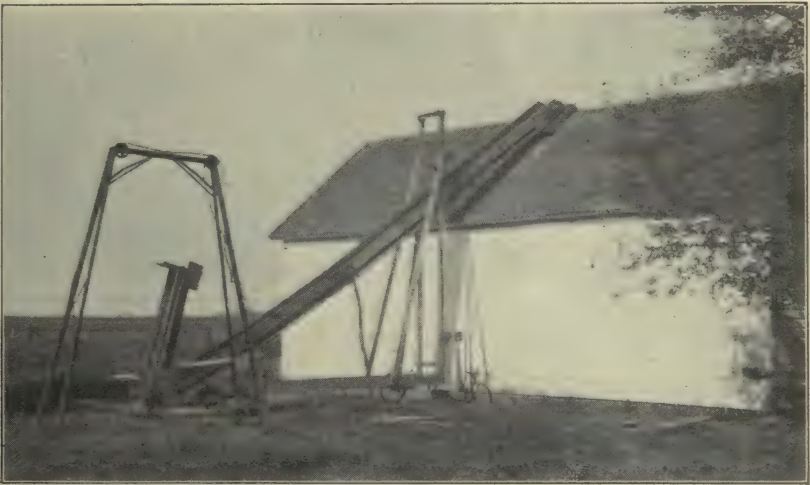


FIGURE 26.—A portable elevator with grain hopper in raised position. This granary is a little too long to permit of filling it through the one central hatch door in the roof

other structures. Grain may be elevated through a gable door or window, as shown in Figure 25, or through a hatch, as illustrated in Figure 26. The power elevator permits of grain storages of greater height, as shown in Figure 27, and relatively cheaper construction than those in which hand methods of filling are employed, because of the smaller foundation and smaller roof required for the same storage capacity. Figure 28 shows a granary with a central cupola to which the grain is raised by means of an elevator and from which the grain is then spouted to any of several bins. The central cupola permits of greater ease in handling the grain spouts when the grain is distributed to the several bins. The windows in the cupola light the interior of the granary and also provide a means of ventilating the building.

Stationary cup elevators, usually operated by belt power, may be installed within either an old or a new storage building. An elevator



FIGURE 27.—A farm granary which because of its height and arrangement makes the use of a portable elevator advantageous. The grain spouts allow of the removal of several hundred bushels of grain by gravity



FIGURE 28.—This granary is filled by means of a portable elevator through the central cupola, which is an improvement on the covered hatch

leg extends to a sufficient height to permit delivery of the grain to a central swinging spout whereby it may be distributed to any bin. The spout should have a slope of not less than 40° . Either a pit or a hoist dump may be used in connection with this type of elevator. In order that the grain shall flow readily from the dump or bin to the elevator boot and from the head of the elevator to the bins, the storage structure should be designed in accordance with the dimensions of the equipment to be installed. The necessary information should be obtained from the manufacturer of the equipment. In many instances it has been found, after the building was up and the elevator on the ground, that it could not be installed to the best advantage—being either too long or too short, or possibly too wide,

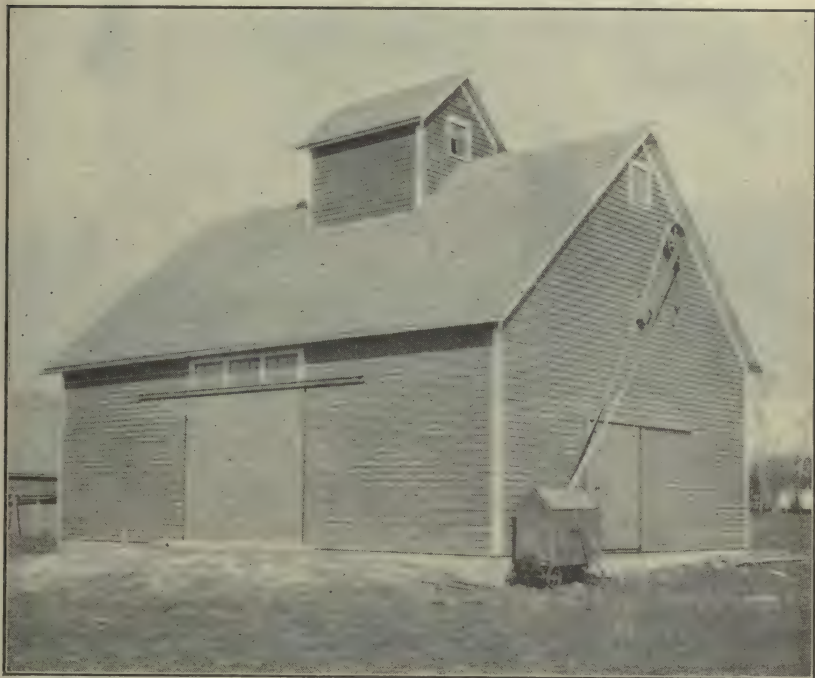


FIGURE 29.—A farm elevator 26 by 38 by 12 feet, balloon framing. Bins are filled by means of an inside cup elevator, driven by a portable engine, which may also be used to drive a feed grinder by belting through the door. Windows over the driveway door light the interior permitting inside work during bad weather

for the space allotted. Both the pit, or underground hopper, and the elevator boot should be protected against the entrance of water. Provision should be made for easy access to the boot with ample room for cleaning and repairing. It should be thoroughly cleaned at the end of the harvest season as grain left in the boot may spoil and affect the grade of grain handled later.

Elevating machinery is practically indispensable in handling large quantities of bulk grain because of the saving in time and labor. It may be used to deliver grain from wagon or truck to bin, from bin to bin, from bin to wagon or truck, and from wagon or truck to railroad cars.

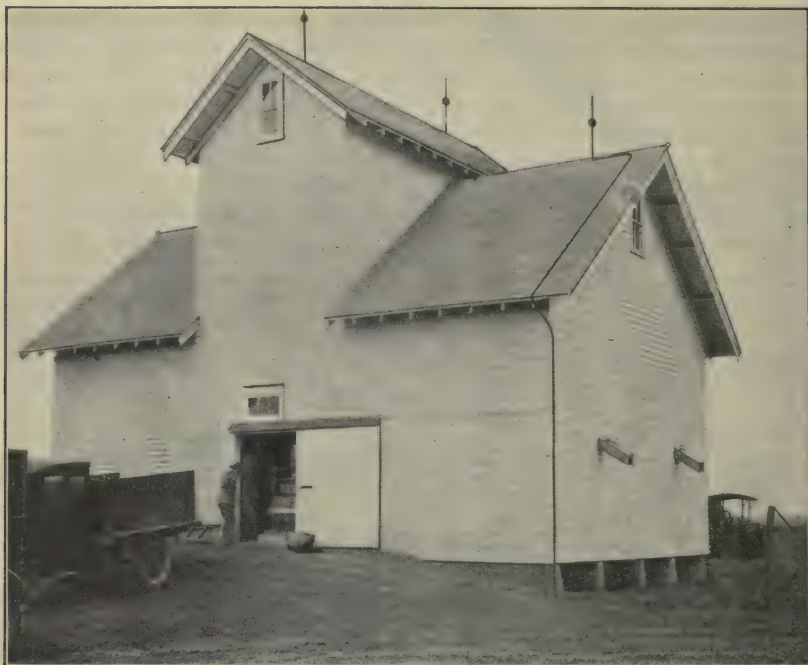


FIGURE 30.—A well-equipped farm elevator with facilities for cleaning and elevating the grain. The grain spouts decrease labor cost in handling grain. Lightning rods protect the building and contents. Note high foundation



FIGURE 31.—Type of farm grain elevator of crib construction suitable for storing from 6,000 to 10,000 bushels. The storage contains 10 bins with inside dump and elevator, and space for cleaning and grinding machinery. Design No. 1878. Estimated cost, not including equipment, from \$3,000 to \$5,500, according to capacity

TYPES OF STORAGE

The farm storage may consist of an elevator, granary, portable bins, or emergency bins.



FIGURE 32.—Type of farm grain elevator of balloon construction suitable for storing from 4,000 to 6,800 bushels. The storage contains four hoppers and five partly hoppers bins, central driveway, space for cleaning and grinding, and elevator. Design No. 2394. Estimated cost, exclusive of machinery, \$2,500 to \$4,000, according to capacity.

ELEVATORS

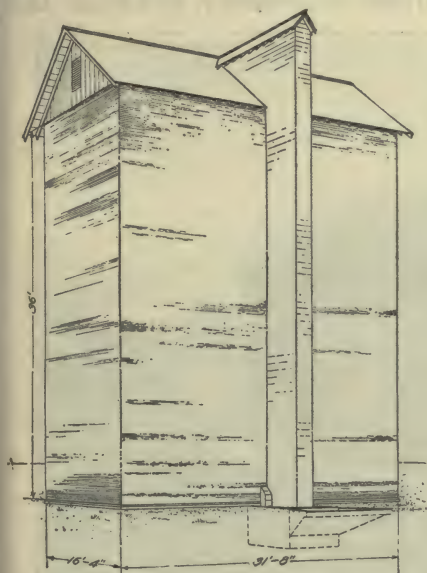


FIGURE 33.—Two-bin crib grain storage with outside dump and inclosed elevator. A shed for grinding and cleaning may be added. Design No. 2297. Estimated cost, exclusive of machinery, from \$2,500 to \$3,000.

The farm grain elevator was developed to reduce the cost of handling and storing grain on large grain-producing farms. It has also come into use on stock farms where large quantities of grain are fed. In such structures extra space and equipment are desirable for the handling of grain in conditioning, cleaning, and grinding. The amount and kind of equipment required for these purposes depends upon whether the grain is to be sold as market grain or seed, or is to be used on the farm for feed. The farm elevator may easily pay for itself in a short time through the prevention of overheating of high-moisture grain by making it possible to transfer the grain from bin to bin to reduce its moisture content, and through the removal of foreign material or dockage from the grain before it is sold on the market. Figures

15, 29, 30, 31, 32, and 33 illustrate several types of farm grain elevators.

GRANARIES

The permanent granary is usually of smaller capacity than the type of storage classed as an elevator and may or may not be filled by machinery. It often may be so located that the natural ground



FIGURE 34.—A hillside granary with wagon ramp and retaining wall on the filling side. A 6-inch space between the masonry and the frame walls provides for air circulation between them. An 8-foot clearance beneath the floor permits the filling of wagons through spouts in the bottoms of the bins

levels permit of handling by gravity all or a large part of the grain going into or out of the granary. To permit of this, a little grading or other construction work sometimes is necessary to obtain the



FIGURE 35.—A farm granary with four bins of 600 bushels capacity each. High foundation keeps the timbers dry. Inadequate bearing afforded by the center 2 by 4 inch sill caused crushing of joists on lower edges

required floor and drive levels. Such an arrangement is desirable provided the extra cost of construction does not exceed the cost of mechanical equipment for handling the grain. A granary in which

the grain is handled partly by gravity is shown in Figure 9. Figure 34 illustrates an instance of gravity handling in which the extra cost of construction—chiefly retaining walls, excavation, and fill—would exceed, at present prices, that of elevating machinery.



FIGURE 36.—A common type of granary 14 by 24 feet, with four bins each of 450 bushels capacity, which may be filled by hand or by means of a portable elevator. Space for cleaning and treating seed is provided. Design No. 984. Estimated cost, \$1,000



FIGURE 37.—A combination shop and granary, 24 by 26 feet, with concrete walls and metal roof

Figures 35 and 36 show permanent granaries in which the grain is loaded and removed by hand. Space no longer needed for horse stalls, or other unused space in the stable or in the loft above, often

may be utilized for this purpose. Wheat stored in bins within a barn has greater protection from the heat of the sun than that stored in small, separate granaries. The portable elevator often makes available for grain storage space that otherwise would be inaccessible.

Grain bins often are built in combination with storage space for other crops, or for machinery, implements, or automobiles. Figures 6, 37, 38, and the cover page afford suggestions of arrangement which may be of aid to those contemplating the erection of a storage building.

PORTABLE BINS

Portable bins may be of wood or sheet metal and should be so built that they may be easily moved from place to place. They may



FIGURE 38.—A combination granary and machine shed with metal sheathing. The grain bins are on both sides of the central driveway. Machinery is stored in the sheds at the sides. The grain is handled with a homemade cup elevator

be of knockdown (fig. 39) or of rigid construction, the latter usually being provided with skids for ease in moving. (Fig. 40.) They range in capacity from 500 to 1,500 bushels, most of them holding less than 1,000 bushels.

The knockdown type is used chiefly in locations where it is impracticable to move bins of rigid construction or where it is desired to shelter the bins, when not in use, in a compact space. Because of the greater difficulty in keeping them grain tight, knockdown bins are not as desirable as those of rigid construction.

The principal advantage of portable bins is the saving of labor which results from their use in the field. The grain can be stored in them directly from the thresher, or with a short haul from the

thresher or combine, thus saving time and hauling expense during the busy season. The life of a portable bin is shorter than that of the permanent forms of storage. The latter, usually, are the more

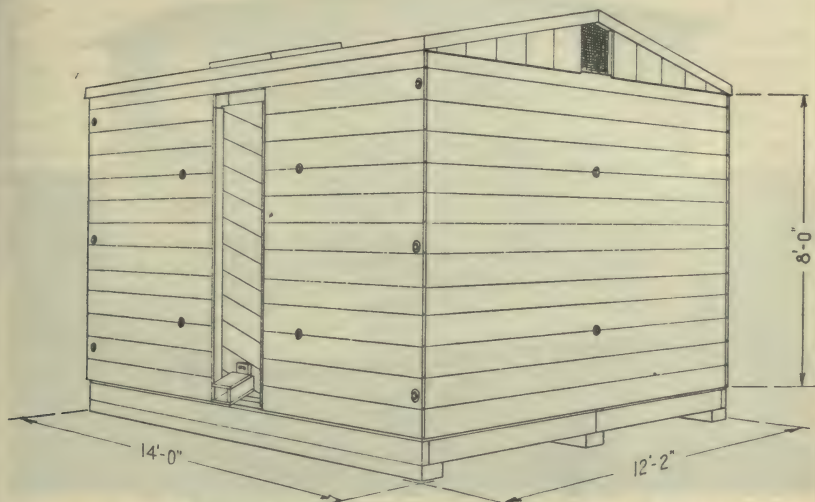


FIGURE 39.—Knockdown bin of 1,000 bushels capacity. Design No. 2391
Estimated cost, \$250

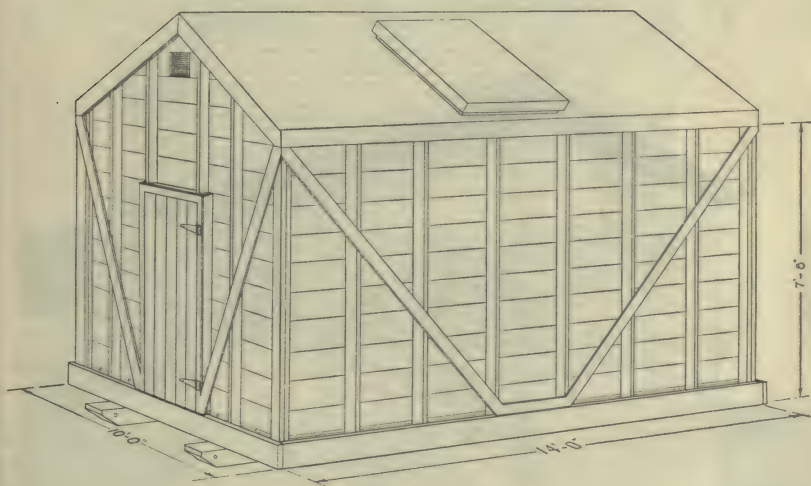


FIGURE 40.—Portable wooden grain bin holding 660 bushels. Design No. 2294.
Estimated cost, \$150

economical when large quantities of grain are to be stored. Some of the common forms of portable bins are shown in Figures 40, 41, 42, and 43.

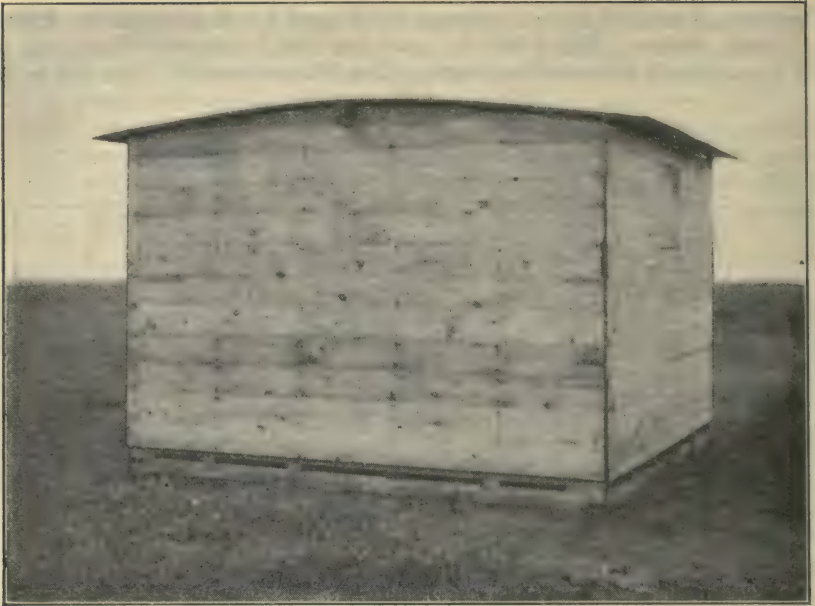


FIGURE 41.—A portable grain bin of box-car type 10 by 10 by 6 feet having a capacity of 480 bushels



FIGURE 42.—A portable bin mounted on skids used temporarily as a summer bunk house

METAL BINS

Galvanized-metal bins, as both portable (fig. 43) and permanent (fig. 44) installation have been used satisfactorily for the storage of bulk grain in many localities. They are easy to handle and erect, are vermin-proof, and provide fire protection. Their cost is not prohibitive. Because of their light construction they are often subjected to careless handling and consequent damage in moving, and they are easily damaged by the wind. Bins more than 10 feet in diameter, especially when of light-gage metal, should be strongly braced inside to withstand wind pressure when empty. As portable bins they should be anchored with guy wires to temporary posts.

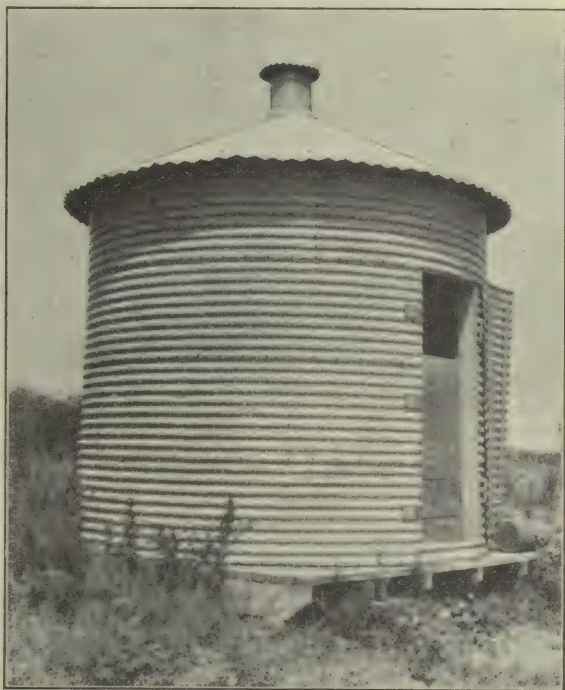


FIGURE 43.—A 500-bushel portable bin of corrugated metal, mounted on skids

When set in permanent locations they should be firmly anchored to concrete foundations. The durability of metal bins is dependent upon the gage or weight of the metal and the quality of the galvanizing. For long life the metal should be of not less than No. 20 gage. Lightweight metal has less structural strength and is subject to rapid corrosion unless well protected by paint.

A portable metal bin of 500 bushels capacity costs from \$90 to \$150 and a 1,000-bushel bin from \$125 to \$200, depending upon the gage and quality of the metal. To these prices the cost of erection must be added and, if the location is to be permanent, the cost of suitable foundations. Generally, erection requires one day's time of two men. Foundations will cost from \$15 to \$35 according to the kind and local conditions.

EMERGENCY STORAGE

Emergency, or temporary, storage sometimes is necessary because of an unusually large crop, an abnormal market situation, accidental loss of permanent storage, lack of trucks or wagons, bad roads, or some other circumstance.

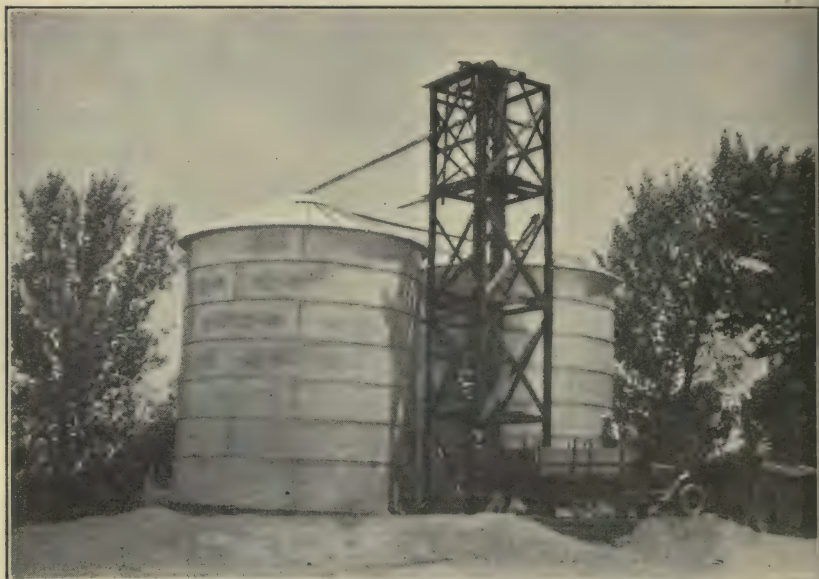


FIGURE 44.—Two metal bins with outside bucket elevator. This may be erected quickly to serve either as a temporary storage or as the beginning of a permanent structure. Other bins may be added and the elevator may be inclosed

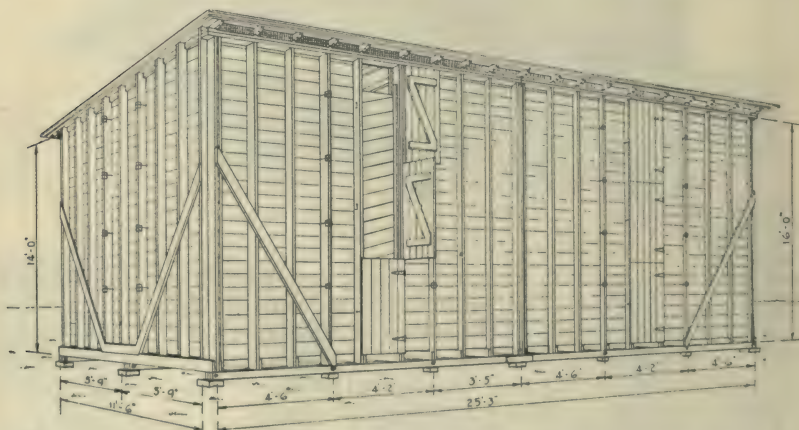


FIGURE 45.—Two-bin temporary grain storage of 2,800 bushels capacity. Additional bins may readily be added at the ends if desired. Design No. 2393. Estimated cost, \$600

Generally, grain in temporary storage should be protected from the weather and from ground moisture. Figure 45 illustrates temporary bin providing such protection. In the semiarid region

grain sometimes is piled directly on the ground for a short time with or without a retaining inclosure. Grain so stored is subject to damage by rains, as well as by rodents and other field pests, and must be fenced in, to prevent loss from livestock. Such storage is illustrated in Figure 46. The greatest damage from moisture, to

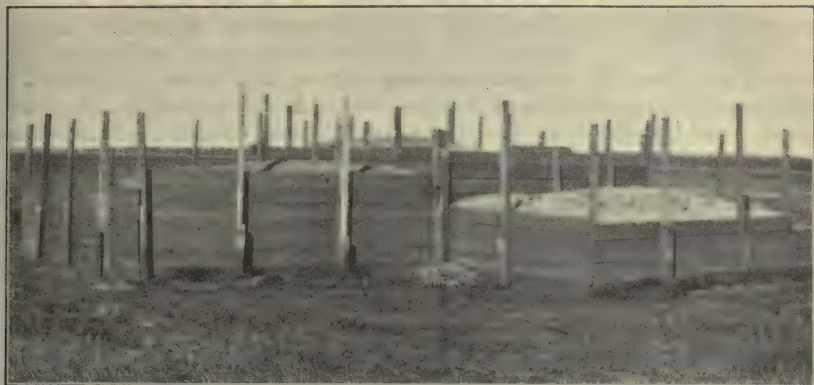


FIGURE 46.—An emergency storage built of posts set in the ground and 1-inch boards. It affords no protection from weather. Spoiled grain was found at the top and bottom of the pile and next to the board walls

grain piled on the ground in the open, occurs over the surface and at the bottom of the pile. Waterproof paper, laid on the ground, lends protection against damage from ground moisture. Heaped grain suffers less damage than that piled with a flat surface.



FIGURE 47.—A temporary grain storage of metal with roof blown off. The grain is covered with wild hay

A better type of temporary storage is shown in Figure 47. The higher metal inclosure affords better protection from field pests and livestock. A covering of hay can not be recommended as it affords little or no protection from rain. Grain stored in this way usually takes a lower grading when marketed than it would had it been properly stored.

Portable metal bins often are used in emergencies. In localities where they are readily available the time and labor saved by the purchase of ready-made bins may offset any additional cost.

Grain sometimes is stored temporarily on the floor of or in bins erected in buildings designed for other purposes. Figure 48 is an interior view, taken during construction, of a new type of machine shed which has been developed in southwestern Kansas. It provides space for the storage of combine harvesters and other machinery, or for the temporary housing of harvested grain. The stability of this particular structure would be increased by the addition of wind bracing and the stiffening of some of the roof members.

LABOR-SAVING DEVICES

There are a number of minor features of storage design which save time and labor in the handling of grain. Grain-discharge spouts, set in the sides of bins, as shown in Figures 6, 27, and 30,

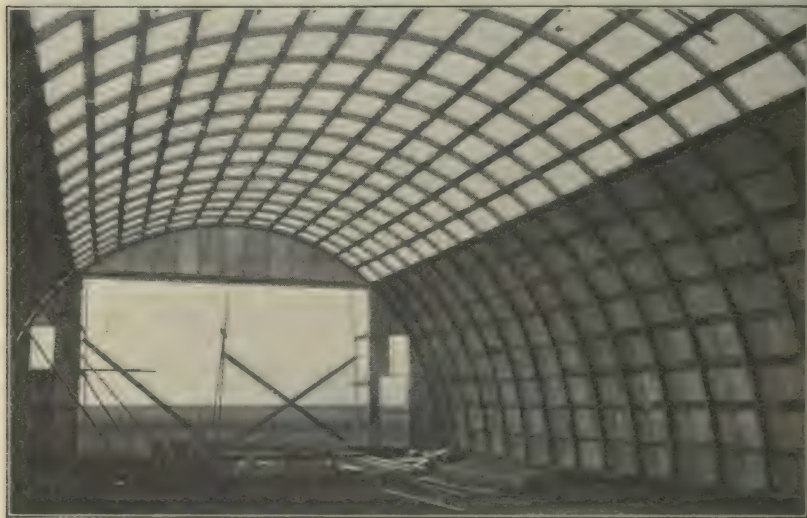


FIGURE 48.—An interior view of hangar type of machine shed, 40 by 100 feet, under construction. It will be used also for temporary storage of grain. The ribs are built up of 1-inch boards and are spaced 4 feet apart. The covering is of corrugated metal.

expedite the unloading of grain bins. When properly placed, they permit of the unloading by gravity of a large part of the contents of the bins, thus saving considerable manual labor or mechanical power. The spouts shown in Figure 6 are of little value because of the small quantity of grain above the spout level.

A swivel metal spout in the bottom of an overhead hopper bin is shown in Figure 49. A lever attached to the gate would make for greater convenience in operation. Deep bins should be equipped with metal discharge spouts, or with wood spouts that are banded with metal, and fitted with metal gates which are easily operated against the pressure of the grain.

Figure 50 illustrates the use of a scoop door which serves as an apron when the bin is being filled and as a chute when the grain is being removed. It is preferable to the cloth or sack apron shown in Figure 2 as less grain is spilled upon the ground. The door illustrated is 30 by 36 inches and is somewhat larger than those in common use. The bottom of this door is 7 feet above grade and is a little too low to permit of filling the bin to full capacity; grain may be scooped easily to a height of 8 or 8½ feet. (Fig. 24.)

Figures 45 and 51 show the proper method of making retaining boards for high bin doors. Cutting the boards at an angle or bevel makes it possible to remove them easily without raising each one to the top of the door. Moreover, they are less apt to bind than are square-cut boards such as are shown in Figure 43. The device

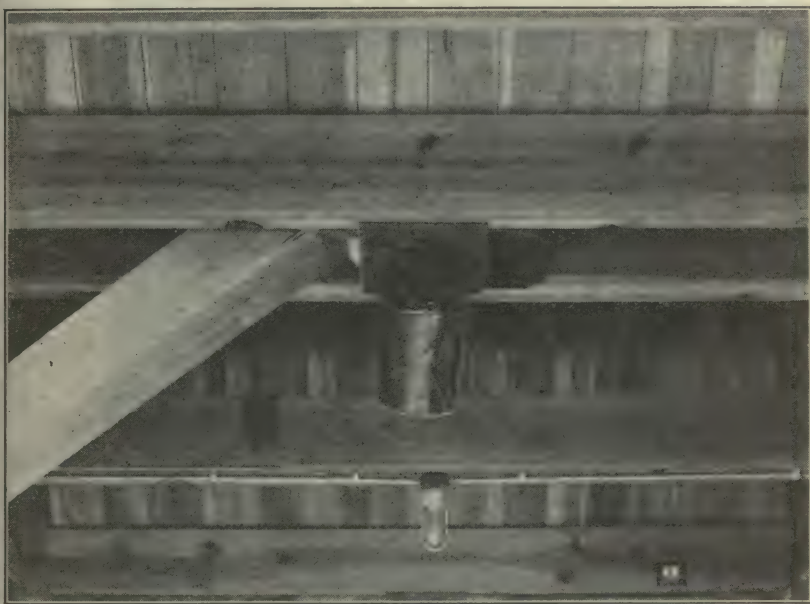


FIGURE 49.—An adjustable swivel grain spout in the bottom of an overhead hopper bin. Metal spouts are more easily operated and are more durable than wood spouts

occupying the lower part of the door opening (fig. 51) is useful when small quantities of grain are to be removed from the bin as in the daily feeding of stock. If the opening is made 2 feet 4 inches wide with a gate in the top, a bushel basket may be filled quickly. A smaller opening will serve for scooping.

Owing to the use of both trucks and wagons of varying lengths in hauling grain to the storage elevator, a square dump opening with a heavy hinged door and dump logs in fixed position are often a disadvantage. The logs and the open hinged door fix the position of the rear wheels of the truck or wagon, which may be too long for the logs. Improved equipment consists of a long dump opening fitted with a heavy iron grating, over which loaded trucks or wagons may be driven, and a wagon hoist of hand or air-lift type so placed that the grain from the shortest of wagons or trucks will fall on the

grating. Grain from longer vehicles also falls on the grating but farther from the end nearest the hoist. The grating usually consists of $\frac{1}{2}$ by $3\frac{1}{2}$ inch iron bars spaced $2\frac{1}{2}$ inches apart and tilted in the direction of travel to facilitate the flow of grain. The grating may be made in sections permitting of ready removal.

PLANS AVAILABLE

The plans referred to in this bulletin should be of help in planning and erecting suitable structures. They are intended to meet, in a general way, conditions commonly found on farms in the wheat belt.



FIGURE 50.—A grain-bin door which may be used as an apron when unloading a wagon, as a chute when loading it

They may be modified with respect to dimensions, arrangement, and details of construction. Complete working drawings for the storages shown in Figures 31, 32, 33, 36, 39, 40, 45, and that referred to in the legend of Figure 3, may be had by those who contemplate building, upon application to the Division of Agricultural Engineering, Bureau of Public Roads, United States Department of Agriculture, Washington, D. C. In requesting a plan reference should be made to the design number given in the legend. Working drawings

for the existing buildings, photographic views of which are presented, can not be furnished. However, many suggestions may be obtained by the practical builder from the illustrations.

It is not feasible to state definitely the cost of storages erected by individual farmers from plans indicated as being available. Prices of materials vary with kind and locality. The cost of rural labor varies with locality and time of year. The efficiency of the labor employed and the experience and judgment of the builder in planning and executing the work are important cost factors.

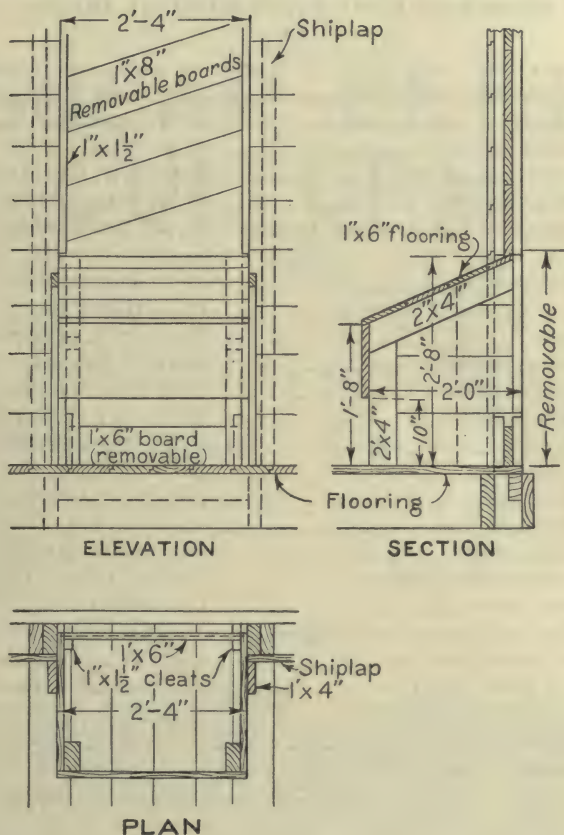


FIGURE 51.—Retaining boards for high bin-door openings. At the bottom of the opening is a scoop door which may be made to fit any opening

As a general guide to those considering the erection of any of the grain storages for which plans are available, estimated construction costs have been given in the respective legends under the illustrations. These estimates are based on prices of \$50 per thousand feet for framing lumber and \$60 for matched lumber, the labor cost being based on the best information available. A more accurate estimate may be obtained by submitting the bill of materials to local dealers. Information regarding the labor cost may be obtained from local carpenters or builders.

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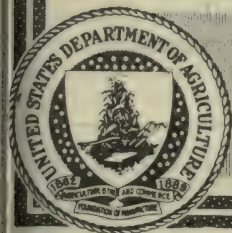
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U. S. DEPARTMENT OF
AGRICULTURE

FARMERS' BULLETIN No. 1637

SUGAR-BEET
CULTURE

in the
HUMID AREA OF
THE UNITED STATES



THIS BULLETIN outlines the practices found successful in sugar-beet growing in those areas of the United States where beets are grown dependent upon natural rainfall without recourse to irrigation.

The area adapted to sugar beets is more or less restricted to districts where soil and climatic conditions are especially favorable. An adequate supply of moisture, especially during the growing season, soil of a proper type, and a long, moderately cool growing season are essential. The adaptability of the sugar beet has permitted its culture on a wide range of soils, but the more satisfactory yields are generally secured on the heavier types. The soil should have good depth, fairly high organic content, adequate drainage, high moisture-holding capacity, and a favorable soil reaction. When properly grown, the sugar beet fits well into a rotation, furnishes a high return, and is valuable for the proper maintenance of soil fertility and tilth.

In the culture of sugar beets intensive measures are necessary. Careful preparation of the soil for the seed bed, proper planting practices, abundant use of manure and fertilizers, and frequent cultivations are essential in securing satisfactory returns.

Weed control is extremely important, especially in the early half of the season when the beet plants are small and may be injured by their rapidly growing weed competitors.

The sugar beet furnishes, in the form of beet tops and beet pulp, a valuable source of feeding material for use on the farm, and these may properly be considered as additional returns from the beet crop.

This bulletin supersedes Farmers' Bulletin No. 568, Sugar-Beet Growing Under Humid Conditions.

SUGAR-BEET CULTURE IN THE HUMID AREA OF THE UNITED STATES¹

By J. G. LILL, *Associate Agronomist, Office of Sugar Plants, Bureau of Plant Industry, and Research Assistant, Farm-Crops Section, Michigan Agricultural Experiment Station*

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INTRODUCTION

THE SUGAR-BEET PLANT is cultivated primarily for the sugar that is extracted from its root. The sugar is formed in the leaves from water and carbon dioxide through the agency of chlorophyll and sunlight, as simple sugars. During the growing season much of this sugar is used in the growth processes of the plant, but as the growth is retarded in the latter part of the growing period the simple sugar formed is stored in the roots as sucrose. The value of the crop depends upon the weight of the roots produced per acre and their sucrose content. Because of its great adaptability the sugar-beet crop may be grown under very different conditions in a wide range of territory, but for successful production on account of the expense incident to the production of this intensive crop, the yields must be sufficiently high for the crop to compete successfully with the other crops grown, and the sucrose content must be sufficient to permit the profitable manufacture of sugar.

The commercial sugar-beet crop is harvested at or near the end of the period of vegetative growth when the roots have reached their maximum size for that period, and the sucrose content is at the highest point. In most of the sugar-beet districts this is at the end of the first season, for selection has caused the sugar-beet plant to assume the habits of a biennial. That is, when permitted to complete its life cycle, it makes its vegetative growth and stores sugar during the first season, remains dormant over winter, and then resumes growth and produces seed during the second season. The

¹ The investigations upon which this publication is based were conducted at the Michigan Agricultural Experiment Station, East Lansing, Mich., under a cooperative agreement between the Office of Sugar Plants of the Bureau of Plant Industry, United States Department of Agriculture, and the farm-crops section of the Michigan Agricultural Experiment Station. This work, begun in 1923, for the first season was under the direction of E. C. Corman, of the staff of the Michigan station. All chemical analyses in these investigations were made by O. B. Winter, research associate chemist, chemistry section of the Michigan station.

roots may increase in size during the second season, or the period of seed production, but they generally become very fibrous or woody and the sucrose content is usually reduced to such a point that they are unfit for manufacturing purposes.

SUGAR-BEET AREA IN THE UNITED STATES

From the standpoint of sugar-beet production, the United States may be divided into three fairly distinct areas by differences in the climatic or cultural conditions. These are: (1) The humid area, located in the North Central States; (2) the Mountain States area; and (3) the Pacific coast area. About 30 per cent of the total acreage of sugar beets produced in the United States is found in the humid area, about 60 per cent in the Mountain States area, and about 10 per cent in the Pacific coast area. In 1929 the total area devoted to this crop was approximately 717,000 acres.

The humid area comprises the States of Michigan, Ohio, Indiana, Wisconsin, Minnesota, Iowa, Illinois, and part of Nebraska. In this area the sugar beet is grown without the aid of irrigation. The production of the crop is not general over the whole area but is restricted to fairly definite districts where the soil and other conditions are exceptionally favorable.

CLIMATIC ADAPTATION

The sugar-beet crop requires an adequate supply of moisture during the growing season for successful production. In the humid area nearly half of the total annual precipitation normally comes during the months of the growing season, from May to September, inclusive. The quantity of water required by the sugar-beet crop for continuous growth depends almost entirely upon the amount of foliage; and while the precipitation during the early part of the growing season in these districts is probably more than actually required by the growing crop, the quantity normally received during August and September is not likely to exceed what the crop can use. However, great seasonal variations occur in all the sugar-beet growing districts. During October and November, the harvesting period in the humid area, the precipitation is usually much less than during the growing period. On the whole, the greatest success is attained in a season in which the rainfall is equitably distributed throughout the growing season but decreases markedly during the fall or harvesting period.

In addition to the adequate supply of moisture, experience has shown that the sugar-beet crop is favored by a long and moderately cool growing season. All the factories operating in the North Central States are located between the isotherms of 67° and 72° F. mean summer temperature (May to September, inclusive), as shown by the accompanying map. (Fig. 1.)

While it is possible to grow the sugar-beet crop under other temperature and climatic conditions than those indicated, the results so far have not been sufficiently satisfactory to lead to its becoming permanently established in many districts outside of the zone designated. The mere fact that a district or area may be included between these isotherms does not definitely guarantee that sugar beets can be

grown there successfully or profitably. Even though the seasonal temperature and the annual rainfall and its distribution are favorable, the soil types and many other factors, some economic, have restricted the localities within the humid area where the crop can be successfully grown.

In the localities where the sugar-beet crop apparently is permanently established in the humid area, there is reasonable certainty of warm days and fairly cool nights during the growing season. This favors the rapid growth of the crop. Since the sugar-beet root is a vegetative structure, growth will continue as long as temperature and moisture conditions are favorable, and the longer the period during which growth can be continued the higher will be the tonnage. However, the value of the crop depends largely upon the sucrose content, and its storage is not favorably influenced by conditions that permit a continuation of vegetative growth. As the nights become cooler in the latter part of the season, although the

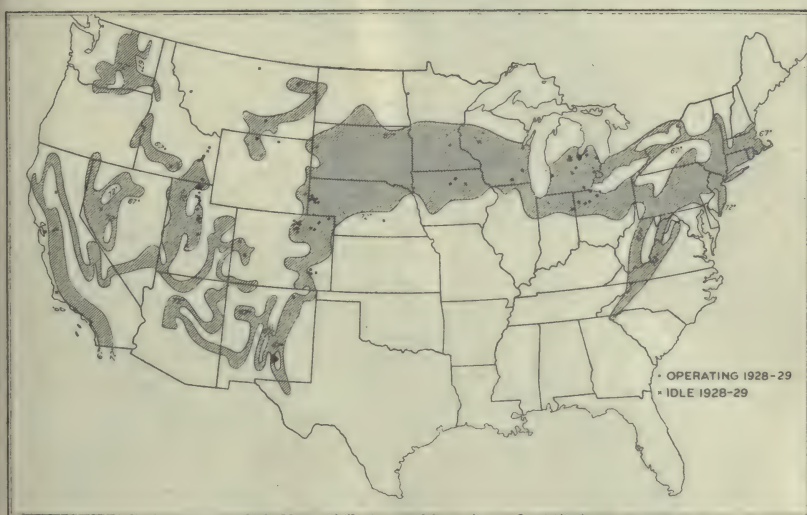


FIGURE 1.—Map showing location of beet-sugar factories

days still remain warm and sunny, vegetative growth is retarded and the storage of sucrose in the root is accelerated.

In general, then, the climatic conditions that favor the production of sugar beets in the humid area are found where the rainfall is distributed throughout the growing period so that growth can be continuous and rapid, where the fall months are sufficiently dry to check the vegetative growth to some extent but not sufficiently dry to stop it altogether, where the summer temperatures are such that growth is favored, and where the fall temperatures aid in checking vegetative growth and promote the storing of sucrose.

SOIL REQUIREMENTS

It is difficult to make any definite statement regarding the type of soil upon which to grow the sugar beets, for they have a very wide adaptation and may be grown upon either mineral or organic

soils. With the mineral soils upon which the greater acreage is grown, the higher and more satisfactory yields are generally secured on the heavier types, such as loams, silt loams, clay loams, and clays, though satisfactory yields have often been obtained upon sandy loams and in some instances upon the still lighter-textured sandy soils. With the organic soils or mucks the yield depends very largely upon the characteristics of the soil. The heavier types of mineral soil are generally better suited to the production of the sugar-beet crop than the lighter soils, and the location of sugar factories in the humid area in general conforms to this broad principle.

Soil type alone is not the determining factor in the production of a satisfactory yield. For successful production of sugar beets

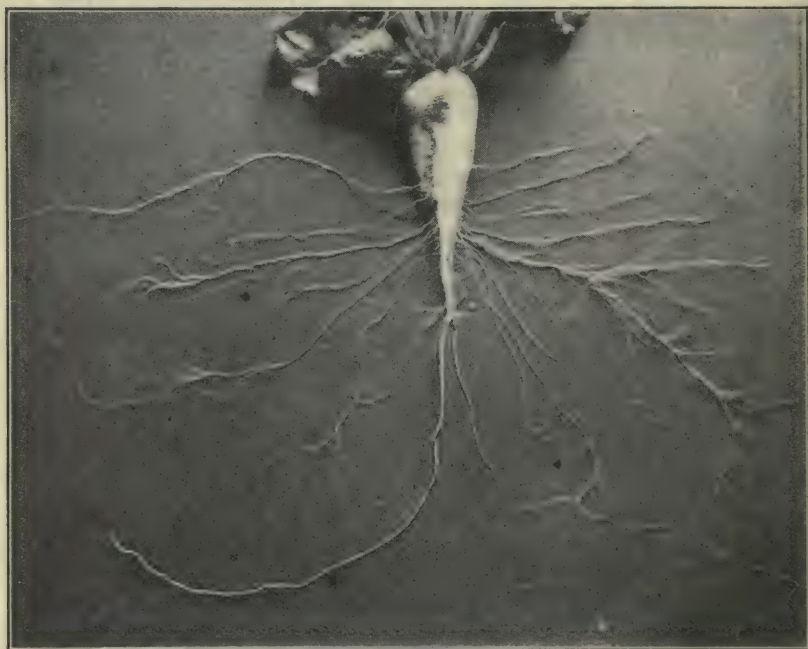


FIGURE 2.—Wide-spreading and deep-penetrating root system of a 3-months'-old sugar beet. The soil had been washed away from the growing plant to avoid breaking the roots

the soil should have good depth, a fairly high organic content (the mucks are characterized by their extremely high organic content), adequate drainage, high moisture-holding capacity, and a favorable reaction.

The sugar-beet plant sends its taproot deep into the soil (fig. 2), and any structure that limits the normal and usual depth to which the root can penetrate decreases the volume of soil upon which the taproot and its numerous small feeding roots may draw for the mineral elements and moisture used in the growth of the plant. Practically all the soils upon which high yields are regularly produced are found to have a depth of at least 3 feet before there is any change in the structure that prevents the penetration of the roots. If the depth of root penetration is limited by soil structures, such

as hardpan or plowsole, or by a high water table, the roots produced under such conditions are very likely to be ill-shaped. On the other hand, if the soil has sufficient depth, the tendency of the sugar-beet plant is to send its roots straight down for a considerable distance. Thus where there is sufficient depth to the soil to allow deep penetration of the taproot the roots harvested will be long and tapering (fig. 3) and of considerably better type than those grown with a high water table (fig. 4), or other unfavorable subsoil condition.

Although it is sometimes possible to secure a fair tonnage from a field where soil structures or drainage conditions prevent the beets from making their normal growth of well-shaped roots, ill-shaped roots materially increase the tailings loss at the factory, and higher yields of more desirably shaped roots could be obtained if the hardpan or plowsole were broken up, or the unsuitable drainage condition corrected.

For the production of satisfactory yields the mineral soils should have a fairly high content of organic matter, which is not only a source of some of the elements that the plant uses but is also a great factor in the retention of



FIGURE 3.—A sugar beet of excellent form

moisture and in influencing the state of tilth. The organic content of the mineral soils is maintained or increased by the use of green-manuring crops in the rotation or by the application of barnyard manure.

In the humid districts much more loss is occasioned by the lack of adequate drainage than is commonly supposed. Lack of drainage limits the depth to which the roots can penetrate and thus limits also the volume of soil upon which the crop can draw for the mineral and moisture supply for its growth. In an undrained soil the height of the water table usually varies according to the precipitation received. When a period of low precipitation occurs the water table will drop away from the comparatively shallow plant roots, and the crop will suffer from drought more quickly on such a soil than on a well-drained soil where the roots have penetrated to a greater depth. Conversely, in periods of high precipitation more damage is sustained on the poorly drained soil, as the water table rises more rapidly than in one that is adequately drained. Instances are found of fields that give good yields where there is a high but

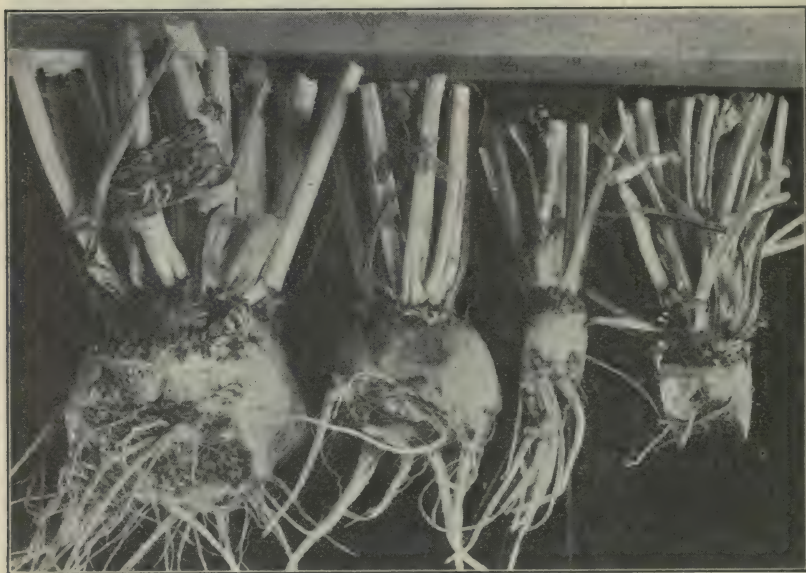


FIGURE 4.—Sugar beets of undesirable shape

constant water table. These yields are possible because of the fact that the constant water table keeps sufficient moisture for continuous growth always within the reach of the plant roots.

The sugar-beet crop, in order to do its best, must grow continuously from the time it starts until within a short time before harvest. In the humid area, where the crop is produced under natural precipitation, it is inevitable that periods of drought occur. If the amount of moisture held within the soil is insufficient to maintain the crop at a high rate of growth during the drought period, growth lags, and the yield is correspondingly reduced. It is during these periods of drought that the heavier types of mineral soil and the organic soils with their higher moisture-holding capacity have a great advantage over the lighter types of mineral soils. It is a common sight to see a sandy spot in a field, or a spot with a sandy subsoil, outlined by the wilting during the middle of the day of all

the beets within the area, while the plants on the adjacent heavier soils show no signs of suffering from drought. The organic matter in the soil, the humus, greatly increases its moisture-holding capacity, and the sugar-beet crop, therefore, seldom suffers from drought as quickly on soils that are high in organic matter as on soils that are low in this important soil constituent. It has been determined that the quantity of water necessary to produce 1 pound of vegetable matter on a productive soil is less than the quantity necessary to produce a pound of vegetable matter on a poor soil. Upon a productive soil the crop is better able to withstand a drought than upon an unproductive one. However, the total quantity of water required to produce the higher yield on the productive soil will be more than that required to produce the smaller yield on the poorer soil.

For the best results with the sugar-beet crop it is believed that the soil reaction should be slightly alkaline. The sugar-beet plant is apparently rather tolerant in this respect, for satisfactory yields have often been obtained upon soils with a slightly acid or even an acid reaction. Field observations and tests indicate that it is much easier to secure and keep a full stand on a soil that has a neutral or an alkaline reaction. If it is possible to secure a good stand of alfalfa or sweetclover on a field where the sugar beets are to be grown, it may be assumed that the soil reaction is suitable for sugar beets. If it is difficult or impossible to secure a good stand of alfalfa or sweetclover where the sugar beets are to be grown, it is quite probable that the soil is sour, and an application of lime is recommended before the sugar beets are planted. On soils where the drainage is poor or where water stands for any considerable length of time during any part of the year, the reaction of the soil is often found to be unfavorable to the sugar-beet crop. Better stands and yields are obtained after a sufficient quantity of lime is applied to bring about the right reaction. In applying lime to the soil intended for sugar-beet culture there is little danger of applying too much and thereby injuring the crop. The application of more lime than necessary to create a favorable reaction is probably a waste of labor and material, since the benefit derived from the surplus is usually relatively insignificant as compared to the cost.

ROTATIONS

The desirability of rotating sugar beets with other crops depends upon several factors. Rotation is not an end in itself but merely a means to an end, and unless some definite benefit is derived there is no practical or logical basis for it. The main reasons for the generally accepted practice of rotation in the case of sugar-beet growing are:

Proper rotation permits the economical utilization of the condition of the soil as left by the preceding crop.

Proper rotation increases the profits by an elimination of work.

Proper rotation protects the crop to a very considerable extent against insect pests, weeds, and plant diseases.

Nearly every properly planned rotation upon a mineral soil will include one crop that adds organic matter to the soil. This may be a legume, but other crops are often used for this purpose. If a leguminous crop is used, the double purpose of adding organic mat-

ter and nitrogen to the soil is accomplished at one time. Of the various green-manuring crops, red clover, sweetclover, and alfalfa are probably the most important. These are sometimes grown immediately preceding the sugar beet and sometimes as the second crop previous to the sugar beets. There is some objection to using either alfalfa or sweetclover immediately preceding the sugar beets, since both these crops are likely to leave the soil in a poor physical condition and the plants, which are difficult to eradicate, may persist and become weeds in the sugar-beet field. On this account many growers favor the use of a green manure as the second crop preceding the sugar beets, the intervening season giving ample time to eradicate any plants of the deep-rooted legume that may have persisted, as well as to reduce the soil to a desirable state of tilth. One other objection to using a green-manuring crop immediately preceding the sugar beets is that in some instances there is greater danger of insect injury. Cutworms and white grubs, as well as wireworms, are often found in grassy, clover sods, and if sugar beets are planted immediately following such a crop insect injury is likely to be sustained. Fall plowing in this case will reduce the danger of injury from white grubs and wireworms, or an intervening crop can be grown in case fall plowing can not be done.

In some rotations that have been very successful with sugar beets, heavy applications of barnyard manure are used in place of a green manure. The success of this practice depends to a large extent upon the quantity of manure that is available, as it requires relatively heavy applications to equal a heavy growth of a green-manuring crop in supplying organic matter.

The crop succession in a properly planned rotation will be such as to leave the soil as free from weeds as possible. This is a factor of great importance. In some places the impression has become established that the sugar-beet crop can be profitably used to clean up foul fields in preparation for other crops. On account of the intensive work which is normally given the sugar beet this is possible, but the net cost is likely to be far greater than is supposed on account of the low tonnage that is usually secured when this practice is followed. It is almost impossible to remove the weeds in a foul field quickly enough to prevent loss of yield by the weed competition, and it is practically impossible to clean up a foul field without losing an appreciable portion of the stand. The sugar beet is a cash crop, and every effort should be made to produce as high a yield at as low a cost as possible. The use of weed-free soil will eliminate work and secure higher yields, thus increasing the profit.

A properly planned rotation gives ample time between the removal of one crop and the planting of the next for thorough preparation of the soil. It has been demonstrated repeatedly that higher yields (1 ton or more) are obtained from the sugar beet upon fall-plowed than upon spring-plowed areas (Table 1), and therefore the preceding crop should be moved from the field early enough to permit fall preparation of the soil for sugar-beet growing. There are some rotations in use in which the soil is left in such excellent condition by the preceding crop that the growers have found it practicable to prepare the soil in the spring for the sugar beets by simply disking

and harrowing. This item alone, where comparable yields are obtainable, increases the profits.

TABLE 1.—*Influence of time of plowing on yield and sucrose content of sugar beets*¹

Time of plowing	Commercial roots per acre	Yield per acre	Sucrose content	Estimated sugar per acre
	<i>Number</i>	<i>Tons</i>	<i>Per cent</i>	<i>Pounds</i>
Fall.....	20,433	14.48	14.06	4,073
Spring.....	19,439	13.37	14.11	3,775

¹ Each number in the table is the result of 1,080 determinations. These determinations were made on sugar beets growing on medium light soil.

Although it is impossible to give definite recommendations for all localities as to the exact crop sequences to use, or even the various crops to use in rotations, it is possible to mention several that have given satisfactory results. These are given in Table 2.

TABLE 2.—*Outline of typical rotations*

Rotation	First year	Second year	Third year	Fourth year	Fifth year	Sixth year
A.....	Sugar beets	Barley ¹	Clover	Beans		
B.....	do	Small grain ¹	do	Corn or potatoes.		
C.....	do	do	do	Corn, beans, or potatoes.	Small grain ¹	Clover.
D.....	do	Oats or barley. ¹	Alfalfa	Alfalfa	Alfalfa	Corn, beans, or potatoes.
E.....	do	Corn	Oats	Wheat ¹	Clover	
F.....	do	Small grain ¹	Clover	Corn	Beans	

¹ Seeded to the following leguminous crop.

PREPARATION OF THE SOIL

The first step in the actual preparation of the soil for the sugar-beet crop in the majority of cases is plowing, though in many localities growers follow the practice of thoroughly disking the soil first. (Fig. 5.) Disking cuts up any trash or material that might have been left on the soil by the preceding crop and makes it easier to turn under such material. It has the added advantage of thoroughly pulverizing the surface soil, so that the portion of the furrow slice that is turned down is already in a fine granular state, and no large openings are left at the bottom of the furrow. Consequently, a smaller number of diskings or rollings with a cultipacker are necessary to firm the soil sufficiently to make a good root and seed bed.

Whether the soil is to be plowed or not and the depth to which it should be plowed depends very largely upon the nature of the soil, the preceding crop, and the equipment available. Shallow plowing is easier and less expensive on all types of soil than deep plowing, but the results obtained with the sugar-beet crop are usually in favor of the deeper plowing. Results of a great many comparative tests

over a series of years at the Michigan Agricultural Experiment Station with different depths of spring plowings show decisively the advisability of the deeper (8 to 10 inch) type of plowing. With the deep plowing the stand was better and the tonnage and the sugar per acre were increased.

Deep fall plowing, 8 or 10 inches, on the heavier mineral soils is entirely practicable, as the effect of the freezing and thawing in the fall, winter, and spring assists very materially in breaking up and mellowing the large lumps of earth that are turned up, and the later work of preparing a good root and seed bed is relatively easy. However, if the same soil is plowed to the same depth in the spring the preparation of a proper bed is much more difficult. On the other hand, if this type of soil is plowed from 6 to 8 inches deep in the spring less difficulty is encountered in preparing a satisfactory bed. With the lighter types, the soil may be plowed to the same depth in



FIGURE 5.—Disking, both before and after plowing, is an important factor in the preparation of the soil. Previous to plowing, the disk cuts up all trash and other materials left on the soil and makes it easier to cover them when plowing, as well as to fine the portion of the furrow slice that is turned down. After plowing, disking breaks up the clods and lumps and reduces the soil to a better condition

either the fall or the spring without encountering difficulties in preparing a good bed. However, there is one disadvantage connected with plowing some of the lighter types of soil in the fall, for the effect of the frost is often so great that the structure is entirely broken down, and the soil is nearly as compact in the spring as it was in the fall before plowing. With the mucks, plowing often renders them so loose that extreme difficulty is likely to be encountered in compacting them sufficiently to form a good root and seed bed. Under these conditions it is often advisable to omit plowing in the preparation of the soil for the crop.

Following the plowing, whether the soil is light or heavy and whether the plowing was done in the fall or in the spring, the soil is usually thoroughly disked. (Fig. 5.) The disk cuts up the larger pieces of the furrow slice that have not fallen apart and stirs the soil so that the finer and looser material has an opportunity to move downward and fill up the crevices and holes between

the larger lumps and between the furrow slice and the bottom of the furrow. Following the disking, the cultipacker, or similar roller (fig. 6), is used to firm the soil and to crush lumps or clods that have been brought to the surface. With the organic soils heavy rollers are ordinarily used in place of the disk, and the cultipacker is used to firm the soil. Where the soil is not brought into the desired condition by the first set of operations the disking and rolling with a cultipacker are repeated as many times as is thought advisable. When the root bed has been thoroughly prepared the soil is sufficiently firm so that a person can walk upon it without sinking much over one-half inch, yet it has enough "give" to permit the roots to develop within the soil. If the root bed is too compact the beets have a tendency to rise out of the ground during the period of rapid development.

For the best possible condition for germination it is generally necessary to go over the surface with a smoothing harrow several



FIGURE 6.—Rolling. In the preparation of the seed bed, implements of this sort are used to crush clods and firm the soil

times. Usually the last harrowing should be at right angles to the direction in which the rows will run, so that the marks left by the harrow will not be confused with the drill marks, and the drilling can be accomplished more accurately. Many of the growers in localities where the sugar-beet crop is regularly grown wait a few days after the seed bed is prepared and then rework the soil before planting, in order to destroy all weeds that have started to grow.

The opinion that the sugar beet is "hard upon the soil" and that its culture decreases soil fertility more rapidly than is the case with other crops is sometimes expressed by farmers who otherwise are well informed. The results of chemical analyses to determine the amount of plant-food elements removed from the soil by a normal crop of sugar beets in comparison with normal yields of potatoes, wheat, corn, or beans show the sugar beet to be lowest in nitrogen and phosphoric-acid requirements of any of the crops mentioned, and slightly less in potash requirement than the potato. The chemi-

cal analyses therefore do not warrant the assumption that the sugar beet is a "soil robber."

However, it must not be expected that every soil can continue to produce good crops indefinitely without the use of fertilizers to replace the plant-food elements that have been removed from the soil, no matter what crop has been produced. In the humid area it is a general practice to apply a fertilizer of some kind to the soil for the production of the ordinary crops whether sugar beets are grown or not.

USE OF FERTILIZERS

Barnyard manure is perhaps the most common as well as the best fertilizer to use with the sugar-beet crop in almost all localities where sugar beets are grown in the humid area. Not only does the manure applied increase the organic content and moisture-holding capacity of the mineral soil, but it also adds some of the mineral elements that the plants use and improves the tilth of the soil as well. On organic soils or mucks the application of barnyard manure often increases the bacterial activity within the soil, thereby increasing its productiveness. The quantity of manure used is generally limited by the quantity that is produced on the farm and is seldom more than 10 tons per acre. The manure is not always applied immediately preceding the sugar-beet crop, for it is often found that greater benefit is derived by applying it for the cultivated crop preceding the sugar beets. This practice gives ample time for the manure to become incorporated within the soil, as well as opportunity to get rid of any weeds that may have been carried on to the field in the manure.

Commercial fertilizers are often used for the sugar-beet crop, but the mixture necessary and the quantity to apply for the best results depend upon the soil and the farming system followed. The quantity applied per acre varies widely, but the common practice is to apply one or two sacks of 125 pounds. This may be applied broadcast a short time before the crop is planted and harrowed into the soil, or it may be sown with the seed by using a drill with a fertilizer attachment. In some cases the growers prefer to broadcast part and sow the remainder with the seed.

The results secured from the use of commercial fertilizers vary widely. However, the value of the practice is not to be minimized, for the profit obtained when the proper fertilizer is applied in an adequate quantity is usually considerable, and therefore the question of a possible increase in the profit from the crop by the use of commercial fertilizers is urged upon the attention of every grower.

In order to determine the effect of fertilizers of different formulas upon both tonnage and sugar production, cooperative² projects have been carried on with different growers in the sugar-beet districts in Michigan for several seasons.

In the case of the projects on the heavier soils, types that have been under cultivation for about 10 years and which had received applications of barnyard manure as well as having had green-manuring

² The experimental results here summarized are based upon the data obtained in tests carried on in cooperation with the Office of Soil Fertility, Bureau of Chemistry and Soil, U. S. Department of Agriculture.

crops plowed under, the formulas that gave the best results contained no nitrogen and were relatively high in phosphoric acid. The supply of nitrogen in the soil in this case had been maintained by the applications of manure and by plowing under the green manure, and the availability of the potash present in the soil had been increased by the organic acids liberated by the decomposing organic matter. In the case of the experiments with the lighter soil types where there had been no applications of manure and no green-manuring crops turned under, the formulas that gave the best results contained relatively large amounts of nitrogen, were high in phosphoric acid, and contained less potash. The results of these tests with two soil types will serve to illustrate the fact that variations in the formula are necessary for different conditions both as to soil type and farming practices. If the farming practices, through the application of manure and the plowing under of green-manuring crops, maintain the organic matter and nitrogen in the soil to a high point, the fertilizer necessary to secure the best results will be different from that necessary where the organic matter and nitrogen content have both been decreased through poor farming practices.

Experimental work indicates that poor returns are obtained and that actual loss may result from applying a fertilizer that does not supply the elements that are deficient in the soil. The figures that have been obtained also show that fertilizers have an appreciable effect upon the quality of the sugar beets, though this effect is less pronounced than their effect upon the yield.

From specific consideration of the field in question, from experience in the response of other crops to the fertilizer elements, and by direct comparison with results from local experiments the grower should determine the appropriate fertilizer treatment to apply.

MACHINERY

For the best results with the sugar-beet crop the best type of machinery should be used in every operation, from the preparation of the soil until the crop is harvested and delivered. It is possible to grow sugar beets without any special machinery, but inasmuch as sugar beets are a root crop and are handled differently from other ordinary crops, the type of machinery that is best adapted for the other crops is not necessarily adapted to them.

The implements used in the preparation of the soil are of the general-purpose types. Thus it is not necessary to procure additional implements for this part of the work. But for the drilling, cultivating, and harvesting, specially-designed implements that fit the crop are needed. Various types of these implements, which serve the crop requirements well, are on the market. Some of these are shown in Figures 7 and 8.

SUGAR-BEET SEED AND PLANTING PRACTICES

The sugar-beet seed as furnished to the grower is not a true seed like a grain of corn or wheat, but is a seed ball composed of the dried flower parts and the seed produced by each flower of a flower cluster. (Fig. 9.) When the beet seed matures, the flower parts dry and the

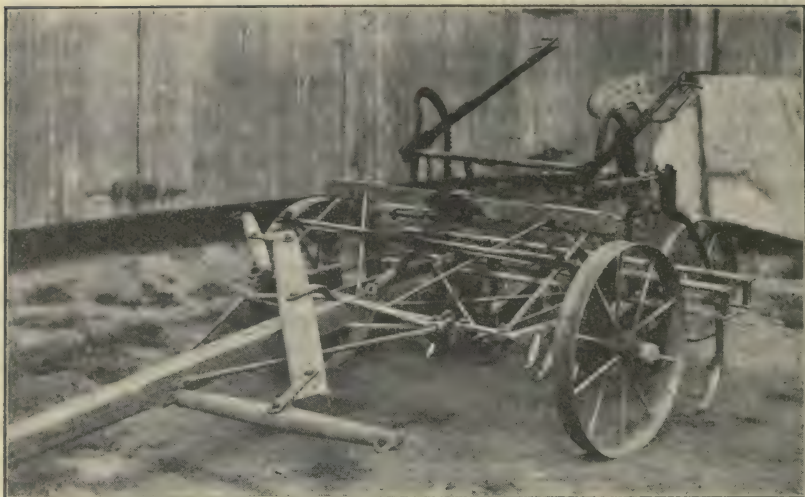


FIGURE 7.—An improved 2-row beet cultivator. In the humid area where fields are sometimes uneven because of the presence of dead furrows or back furrows, a 2-row cultivator stirs the surface of the soil more evenly than a wider machine. Where the surface of the soil is level or even, the 2-row cultivator does not do any better work than the wider machine and is also slower

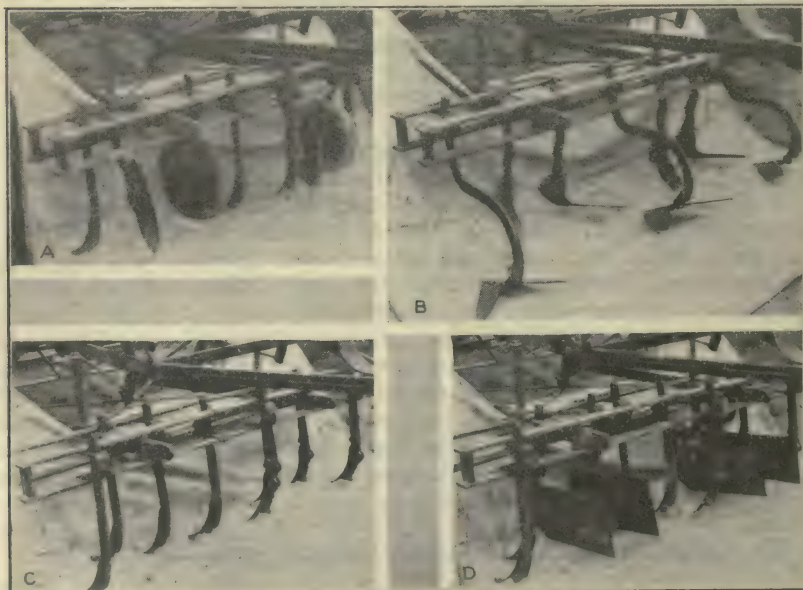


FIGURE 8.—An improved sugar-beet cultivator equipped with a variety of tools to meet different conditions; A, The cultivator equipped with disks and narrow shovels; B, equipped with knives and duckfeet; C, equipped with shovels only; and D, equipped with shields and shovels

seed or germ is held firmly within them. If two or more flowers grow in a cluster, as they usually do, the entire cluster sticks firmly together, and the seed ball resulting consists of all the flowers in the cluster together with the seed produced by each flower. Thus, when the seeds germinate, from 1 to 7 or 8 seedlings may emerge from a single seed ball. The seed balls vary greatly in size on account of the number of flowers that united to form the ball, but apparently this has no relation to the vigor of the seeds, for practically the same results in yield and in sugar per acre were obtained when seed balls of different sizes were planted. However, the number of seed balls dropped per foot in the row by the drill will be materially affected by their average size. In the writer's tests the same drill set was used with the seed balls of the different sizes and approximately the



FIGURE 9.—Sugar-beet flowers, flower clusters, and spikelets with clusters, showing how the sugar-beet seed balls develop

same quantity of seed planted, but because of the difference in size more of the small seed balls were planted than of the larger sizes.

Practically all of the sugar-beet seed that is used in the United States at the present time is imported from Europe. Inasmuch as the sugar-beet crop is grown under contract for the beet-sugar factories and the contract usually stipulates that the seed used will be that furnished by the sugar company, the growers have very little to do with its selection or purchase. The sugar companies realize the necessity of furnishing a high-grade seed and make every effort to provide seed that will give the best results. Many of them conduct test fields in which the various brands of commercial seed are grown in order to determine their relative merit.

The sugar-beet crop is an intertilled one, and the seed is planted in rows so that intertillage is possible. For this purpose drills of

various makes are used. Figure 10 shows a common type. The space between rows used in the humid zone varies from 20 to 22 inches, to as high as 28 inches, with probably the greater portion of the crop being produced in rows 24 inches apart. Many of the growers prefer the wider spacing, as the crop is much more easily worked than when the rows are closer together. In some instances the seed is planted with an ordinary grain drill in which every third hole is left open. This spaces the rows according to the fixed adjustment of the drill. In districts where the bean crop is important, sugar beets are often planted and tended with the same tools that are used for the bean crop. Since the usual space between rows for beans is 28 inches, the sugar beets are often planted in rows of that interval.

The quantity of seed to use per acre for the best results depends upon the climatic and soil conditions and spacing of rows. In general the sugar companies recommend from 15 to 20 pounds of seed per acre. If the standard is 17.5 pounds of seed per acre for a 24-inch

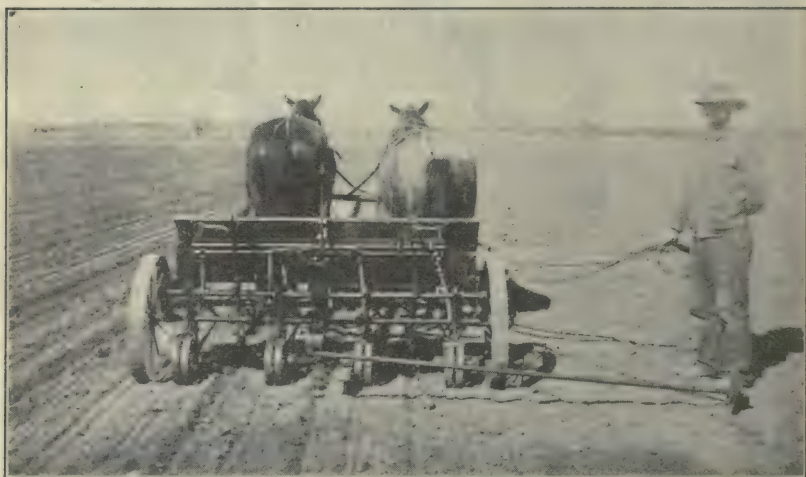


FIGURE 10.—A common type of drill used in planting sugar-beet seed in the humid area. This drill can be adjusted for rows of different widths

row, the equivalent for a 20-inch row would be 21 pounds and for a 28-inch row would be 15 pounds. Experiments conducted at the Michigan Agricultural Experiment Station showed an appreciable difference in yield in favor of 17.5 pounds of seed to the acre when 10 and 17.5 pounds of seed used in 24-inch rows were compared, but a further increase in the quantity of seed did not result in any increase in yield.

If the seed bed has been properly prepared and there is sufficient moisture in the soil for complete germination, the stand secured will be much thicker than can be carried through the season, but it is necessary to use the quantity of seed recommended, so that on soils that are poorly prepared (fig. 11) or under climatic conditions that do not favor germination, or where seedling diseases destroy a large number of seedlings the initial stand will be sufficiently thick so that the desired stand can be secured at thinning. For a good initial stand there should be one or more seedlings every 2 inches in the row.

Many failures in securing a stand of sugar beets have been blamed upon planting the seed either too shallow or too deep. Experiments conducted at the Michigan Agricultural Experiment Station indicate that there is a rather wide range in the depth to which the seed may be planted without materially affecting the stand secured, but the highest yields were obtained with seed planted 1 inch deep.

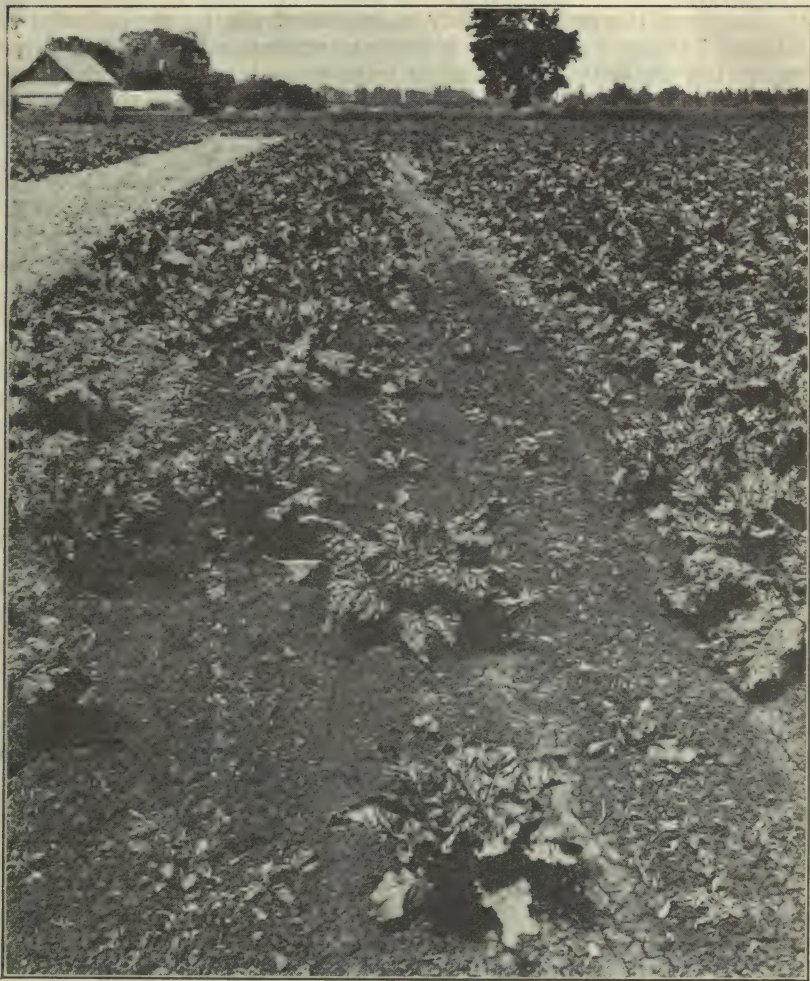


FIGURE 11.—Sugar-beet field showing vacant spaces where the surface soil has not been reduced to the proper seed-bed condition before planting

Since the soil should be warm enough for the seed to germinate readily after it is planted, and since there is considerable difference in soil temperatures at different depths early in the season, the early planting should be relatively shallow—from one-quarter to three-quarters of an inch. With the later plantings, when the soil has warmed to a greater depth and the surface has dried out, a depth of 1 to 1½ or even 2 inches is recommended, depending upon the soil and moisture conditions. With these later plantings, which are made

to the greater depths, when the surface soil is loose the seedlings will have little difficulty in breaking through the soil, but in case of hard rain before the seedlings come through there is danger of a crust forming which they can not break. To break up such a crust, cultipackers, weeders, and smoothing harrows have been successfully used. As long as the seedlings are still below the crust there is slight danger of destroying the stand, but if the leaves are held in the crust any disturbance of the crust is likely to break off the leaves and kill the seedlings. In such cases the grower must depend upon the slower germinating seeds for his stand or must reseed.

For the best development of the crop the sugar-beet plant should be given as long a season as possible in which to grow. It will continue to grow as long as conditions are favorable, and the rate of increase becomes greater as the plants become larger and have more foliage. Thus the growth in a single day in the latter part of the season is many times the gain made in a day or week early in the season. This increasing rate of growth is checked by climatic conditions or harvest in the fall, and in order to take the fullest advantage of the climatic conditions that permit the most rapid growth, early seeding is recommended. It has been demonstrated time and again in commercial fields and also on experimental plots that the highest yields are obtained from the earlier seedings. The differences in the yields obtained from early plantings do not represent the difference in the amount of growth made early in the season alone, but on the other hand do represent the differences in the gains made during the period of most rapid growth. However, it would be a mistake to slight the preparation of the seed bed or root bed in order to plant the crop a few days earlier than would otherwise be possible. Observations and experiments in the humid area indicate that the period in which the sugar-beet crop should be planted extends from the middle of April to the middle of May.

THINNING

Because of the fact that the seeds can not be planted singly, being contained within the seed balls, and as an excess of seed is used, the initial stand is usually much thicker than can be carried through the season, and it is desirable therefore that the seedlings be thinned to a proper stand before there is much competition among them. An experiment carried on at the Michigan Agricultural Experiment Station in which the seedlings were thinned at weekly intervals from the time the crop "rowed through"³ until the end of the seventh week thereafter furnishes some information as to the best time to thin. The results showed a decided decrease in yield for each week's delay in thinning after the end of the second week. There are, however, certain conditions that may make it inadvisable to thin the beets between the first and third week after rowing through. In case of adverse weather conditions the beets may not reach the proper stage for thinning in the same length of time that they did in this experiment where the growing conditions were comparatively favorable. In fields where seedling diseases are killing a large number of

³ The term "rowed through" is used to indicate the condition when the row of beet seedlings can be followed for several hundred feet with the eye. This stage, when the true leaves are just starting, is taken as a basis, because it is the earliest stage at which thinning can be done.

plants, it is a very good plan to wait until the disease is brought under control or has run its course before thinning.

It is not always possible to thin a commercial field of beets at just the proper time, on account of labor conditions. Growers usually contract with the sugar company for the labor necessary, and the companies make every effort to supply it at the proper time, but there are factors involved which make it very difficult at times to supply at once the amount of labor necessary.

At the time of thinning, some of the seedlings will be large and flourishing, while others may be small and spindling. In order to determine the influence that the comparative size of the seedlings may



FIGURE 12.—Blocking and thinning sugar beets. The beets are first blocked by striking through the row with a long-handled hoe, care being taken to leave small bunches of seedlings at about the proper intervals in the row. Following this, another person removes all the remaining weeds and the extra seedlings by hand

have on the yield and sugar production, records were obtained from adjacent plots on which the largest and the smallest seedlings were selected, respectively. The results obtained indicate that there is a considerable gain by selecting the larger plants.

Two distinct methods are commonly employed in thinning sugar beets. In one the row of seedlings is first blocked with a long-handled hoe (fig. 12), care being taken to leave a few seedlings standing undisturbed at about the proper intervals. The extra seedlings and all remaining weeds are then removed by hand. In the second method (fig. 13) the thinners are equipped with small, short-handled hoes, and all the work is completed at one operation.

SOIL SPACE AND THE SUGAR-BEET CROP

The individual sugar-beet plant should be given enough space to insure the best results from the crop as a whole. This is influenced by the productivity of the soil, date of planting, weather conditions, and other factors. This space may not coincide with the amount that will permit each plant to make its greatest development. If the same space is to be given a beet plant when grown in rows 20 inches apart as when grown in rows 28 inches apart, the thinning distance must necessarily be different. Beets thinned 14 inches apart in a 20-inch row will have the same amount of soil space per plant as those thinned 10 inches apart in a 28-inch row. The fact that the beets are a little more evenly distributed over the soil with the 14-inch thinning in the 20-inch row would probably give them an advantage over those grown 10 inches apart in 28-inch rows.



FIGURE 13.—Blocking and thinning sugar beets at one operation. Here each worker is equipped with a small, short-handled hoe which is used to cut out the spaces or to block the beets. The extra seedlings and the remaining weeds are then removed by hand.

Among growers there is a great diversity of opinion as to the proper space to allow per plant in order to obtain the best results from the crop, individual preference ranging from 10-inch thinning to as high as 16-inch thinning with rows of any of the customary intervals.

The experimental work carried on so far in the humid area has shown that there is no "optimum" spacing, since in tests with various spacings ranging from an average of 4 inches to spacings of 20 inches in the row the tonnages obtained were practically the same. As the spacing increased, the size of the roots increased accordingly. This is because the individual sugar-beet plant has the ability to increase in size and thus compensate to a large extent for the smaller number of beets per acre with the wider spacings. This development, however, apparently reaches a maximum, determined by the productiveness of the soil and the inherent ability of the beet to increase in size, beyond which the individual plant can not go if more than about 500 square inches of soil space are allowed. Ex-

tremely wide spacings, such as occur with skips or blank places in the row, result in very inefficient use of the growing area.

Under ordinary conditions a perfect stand after thinning is very seldom found in a commercial sugar-beet field. Even though the thinning is done with great care, there will be spaces within the row that increase the average distance between the beets and decrease the number of beets per acre. The results of definite experimental work have shown that there is a loss of tonnage as the stand becomes poorer. This is not so marked with deviations up to 20 per cent from a full stand, since the beets that remain increase in size and compensate to a large extent for the loss of stand; but as the stand becomes more and more irregular and the spaces between the beets become wider, the increase of size of the remaining beets can not compensate for the loss of stand. Furthermore, as the beets become larger their quality becomes poorer and their value per ton much less than the value of the smaller beets produced where the stand is more nearly complete. It is therefore recommended that every grower make an effort to secure and keep as nearly a complete stand as possible.

CULTIVATION

The cultivating period for the sugar-beet crop may be divided into two parts, the period prior to thinning and that following, but the amount of cultivation necessary in either period depends upon the type of soil, the content of organic matter, the thoroughness with which the soil has been prepared, the weeds that are present, rainfall, distance between rows, and other factors.

Since the sugar-beet seedlings are very small and can not break a crust, it is essential during the period of germination that any crust that forms be broken immediately. To accomplish this the cultipacker, corrugated roller, weeder, or smoothing harrow may be used. Later, after the seedlings have emerged and the rows can be seen, the ordinary beet cultivator and the cultipacker are generally used to break crusts and to keep the surface soil in condition. It is important during this period that this be done, as not only are many of the weeds destroyed but the aeration of the surface soil prevents to a large extent the loss of stand due to seedling diseases. It is during this period that thick seeding is an advantage, for the large number of seedlings in the row make the rows comparatively easy to follow.

In most of the sugar-beet growing districts it is customary to prepare the field for thinning by cultivating and rolling. (Fig. 14.) According to the terms of the labor contract, the hand laborers are to thin the beets and clean out all the weeds to a certain distance on both sides of the row. The cultivation given at this period outlines the space the hand labor is to clean out. After this cultivation it is customary to roll the field, so that the soil is less harsh to the hands and knees of the thinners. Very often the cultivations given at this period are not necessary from the standpoint of the crop but are given to enable the thinners to do better work. Again, after thinning, the fields are often rolled to force the soil back to the plants where the thinners have pulled it away with their hoes.

The number of cultivations given following thinning is determined by the rainfall and the weeds that start. Fewer cultivations

will be necessary on weed-free than on foul soil. These cultivations keep the soil between the rows in good condition and destroy the weeds. The period of cultivation is of indefinite length and terminates when the foliage covers the ground and the crop can be laid by. As the ground will be covered more quickly when the rows are close together, the crop can be laid by sooner than if the rows are farther apart. Types of cultivators have been developed which are fitted to the needs of the sugar-beet crop. (Fig. 15.)

Ordinarily the labor contract calls for two hoeings following thinning. Usually the same labor that did the thinning does this work. The object of the hoeing is to remove all weeds that have started in the row since thinning and that by reason of their location can not be reached with the cultivator, also to stir all the soil in the row that can not be stirred with the cultivator. (Fig. 16.) However, the



FIGURE 14.—Thinning a sugar-beet field that has first been cultivated and rolled. This preparation makes it possible for the thinners to do much better work

contract labor when hoeing usually removes the weeds and “doubles” only and gives slight attention to the stirring of the soil in the row.

HARVESTING

In order that the crop may make all the tonnage possible and store as much sucrose in the roots as conditions will permit, the harvest is deferred as long as it is safe to do so without danger of having the crop or part of it frozen in the ground. However, it is practically impossible to have all the crop harvested at a time that will permit every acre to make its highest tonnage, on account of labor conditions and other factors.

Ordinarily, samples are taken from the commercial fields at intervals from the first of September on, to determine the condition and quality of the crop. When the harvest season approaches harvest orders are given for those fields in which the sucrose content of the roots is sufficiently high to make extraction profitable. When the harvest order is given the grower is required to harvest and deliver

his tonnage at the time specified. This is necessary, as the supply of beets must be such that the operation of the factory will be continuous. If too many beets are delivered while the weather is still



FIGURE 15.—An implement that cultivates four rows at once, thus saving considerable time in this operation

comparatively warm, there is great danger from loss by deterioration of the roots in the bins or piles. The fresher the beets are when sliced, the smaller the loss between the field and the factory.



FIGURE 16.—Following thinning, the beets are usually hoed twice to remove all weeds that have started within the row, as well as the extra beets that were missed at thinning

In harvesting, the grower lifts the beets with an implement that is designed to loosen the beet roots in the soil. (Fig. 17.) After lifting, the beets are sometimes pulled from the ground by hand, knocked together to remove the adhering soil, and then thrown into



FIGURE 17.—A type of riding lifter in which the weight of the implement is kept from resting on the horses' necks by the two small front wheels



FIGURE 18.—Topping sugar beets after they have been pulled and thrown into windrows

windrows or piles so that the topping can be more easily done. (Fig. 18.) At other times the topper, using a knife with a hook on the end (fig. 19), pulls and tops the beets at one operation.



FIGURE 19.—Pulling and topping beets at one operation. The worker strikes the hook on the end of the knife into the crown of the beet, pulls the beet from the ground, grasps the root with the free hand, removes the hook from the crown, tops the beet, and throws the root toward the pile. The tops are allowed to lie where they fall. This method saves a small amount of time as compared to topping from windrows, but the beets usually carry a greater quantity of dirt

In topping, the crown of the beet is removed by cutting directly through the beet at the lowest leaf scar. This is essential, for the sucrose content of the crown is very low, and the purity of the juice in the crown is much lower than in the root. If the beets are not topped low enough the low sucrose content and the purity of the



FIGURE 20.—Beets loaded on a special beet bed ready for delivery to the station or factory. Wagon beds of this kind will hold from 2 to 4 tons

juice in the crown interfere very seriously with the extraction of the sugar.

After the beets are topped they are thrown into piles from which they are loaded into wagons (fig. 20) or trucks for delivery at the

station or the factory. In case it is impossible to deliver the beets within a few hours after topping and piling, the piles should be covered with leaves to prevent loss of weight due to loss of moisture. The longer the beets are to remain in the piles in the field, the more carefully they should be covered. (Fig. 21.) The loss of weight due to evaporation of moisture is not always realized by the growers. Under ordinary harvest conditions the shrinkage in uncovered piles may be more than 1 per cent a day. This shrinkage is strongly cut down by proper covering with beet tops or soil.

DISEASES

LEAF SPOT

Of the plant diseases that attack the foliage of the sugar-beet plant in the humid area, only one, the leaf spot or blight caused by the fungus *Cercospora beticola*, produces any appreciable damage. The fungus which causes this disease lives over winter in the material



FIGURE 21.—Piles of beets in the field covered to prevent loss of weight between harvest and delivery. The weight lost by uncovered piles is not always realized by the growers

left from the preceding beet crop, hence the advisability of rotating the sugar-beet crop with other crops. The conditions that favor this disease are warmth and high humidity. Conversely, the disease may make its appearance at any time after warm weather starts, but severe attacks are not likely to occur unless the weather conditions favor its development.

This disease, as its name implies, is characterized by small circular spots, seldom over one-eighth of an inch in diameter, produced upon the beet leaf. These spots appear first on the older leaves, but as the disease progresses they may be found upon all the leaves. When the older leaves are injured or destroyed the plant responds by putting out new foliage, which may also be destroyed before reaching full size. Thus, during a severe attack it is a race between the plant and the disease as to whether the plant can produce foliage faster than the disease can destroy it. (Fig. 22.) The effect of this disease in all severe cases is to increase the size and height of the crown of the sugar beet, and if the onset is early in the season there

is a loss in both tonnage and sucrose content, but if late in the season the loss is more noticeable in the sucrose content.

SEEDLING DISEASES AND ROOT ROT

Several organisms, the majority of which are present in practically all soils in the humid area, are able under favorable conditions to attack the roots of the sugar beet and to weaken or kill the plant. These organisms cause blackroot or damping off of the seedlings early in the season and are probably concerned in the root and crown rots later on. The development of these diseases is favored by conditions which are unfavorable to the sugar-beet plant, such as poor drainage and poor soil aeration. Conversely, conditions that are favorable to the development of the sugar-beet plant are unfavorable to the development of the diseases. Even though the organisms causing these diseases are present in all of the soils, they are held in check to a considerable extent by rotations in which the sugar-beet crop is not grown upon the same soil very frequently. Therefore, rotation is recommended.

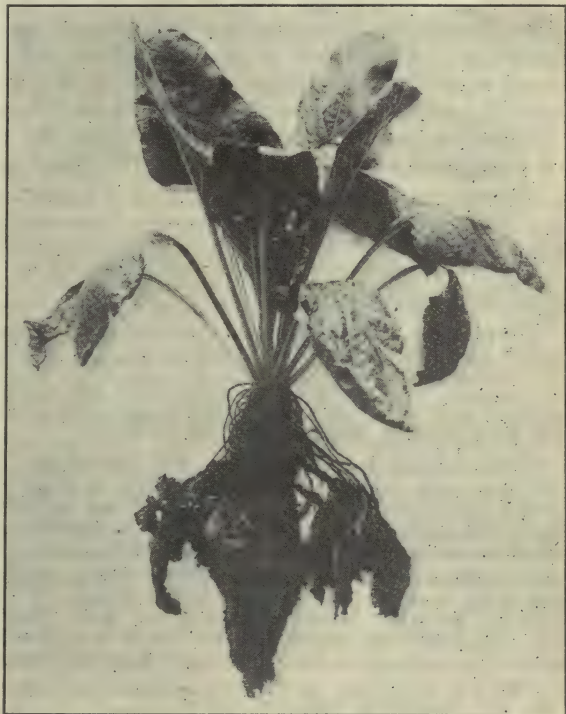


FIGURE 22.—Sugar beet affected with leaf spot. This disease destroys the foliage, and the plant responds by putting out new leaves, which may be destroyed in turn. As this continues, the crown of the beet becomes higher and higher, but the root has very little opportunity to develop

Cultivation to break up crusts and to give aeration to the surface soil early in the season while the plants are small is advisable.

INSECT ENEMIES⁴

Although there are, in the humid area, a number of insects or their larvae that feed upon the foliage or roots of the sugar beet, there are none that cause widespread damage. However, there are some that cause severe local damage, entire fields being ruined while adjacent fields show little or no injury. The most important of

⁴ Prepared by W. H. White, Division of Truck-Crop Insects, Bureau of Entomology, U. S. Department of Agriculture.

these are cutworms, white grubs, wireworms, flea beetles, and grasshoppers.

Cutworms are the young or immature forms of medium-sized dark-colored moths or millers and are usually more destructive in fields that have not been cultivated the previous season, as many species of cutworm moths prefer to deposit their eggs in areas covered with vegetation. The principal damage by cutworms to the beet crop usually occurs early in the season when the plants are small. The cutworms may overwinter in the soil in the half-grown or nearly mature stage, and as soon as the weather begins to warm up in the spring they become active and feed upon any available vegetation. They feed at night, cutting off the rows of seedlings near the surface of the soil. During the day they hide beneath clods of earth or in the soil a slight depth below the surface.

Cutworms can be readily controlled by the use of a poisoned-bran bait composed of the following ingredients:

Dry bran.....	1 peck or 5 pounds.
White arsenic or Paris green.....	$\frac{1}{4}$ pound.
Sirup or molasses.....	1 pint.
Water.....	3 or 4 quarts.

Or, in large quantities:

Dry bran.....	25 pounds.
White arsenic or Paris green.....	1 pound.
Sirup or molasses.....	2 quarts.
Water.....	15 to 20 quarts.

This bait should be prepared as follows:

(1) Thoroughly mix the poison with the bran. This is important. Each particle of bran must carry a little poison in order to get a good kill. When making small quantities, the materials can be mixed in a bucket with a paddle, the poison being added slowly and the bran stirred at the same time. A still more effective way is to mix the poison and bran with the hands; however, since soluble arsenic is absorbed to a slight extent through the skin, there may be some objection to this method. If the hands have any cuts, scratches, or other wounds, do not put them into the bait. When making large quantities, the poison can be mixed with the bran on some flat smooth surface by using a shovel and rake in much the same way as in mixing concrete.

(2) Mix the sirup with the water.

(3) Put the poisoned bran in a bucket or washtub and gradually add the water-and-sirup solution, stirring slowly all the time. A large quantity of water added at one time will wash the poison from the bran, resulting in an uneven mixture.

Caution.—Add only enough liquid to make a crumbly mass. It is a good plan to set aside a little of the mixture of dry bran and arsenic so that if too much water has been used this dry reserve can be added to bring the mixture up to the proper consistency.

Either broadcast the poisoned bait or sow it by hand along the rows. Do this late in the evening so that the bait will not dry out to any great extent before the worms become active. From 10 to 15 pounds of the wet bait per acre is enough for one application. Where the bait is applied directly to the rows the smaller quantity will be sufficient. It may require two or three applications at 2-day intervals to rid the fields of the pest.

White grubs are the larvae or young of the common May beetles. Their normal habitat is in grasslands, but they will feed upon the

roots of other plants. There are many different kinds of white grubs, the majority of which require three years for full development. Therefore, any crop following a grass or clover sod the first, second, or third year is likely to suffer damage.

These pests are difficult to control, but much of the damage to the crop can be prevented by planting the beets in lands that have been under cultivation for at least two years. Fall plowing may also be practiced to advantage against these pests. The plowing should be done before the grubs go deep into the ground to pass the winter. This would be prior to October 10 in many sections.

Wireworms, the larvae or young of the click beetles, sometimes are destructive in certain lands. The kinds of wireworms that are found in the humid beet-growing area favor grasslands, and one species inhabits lands that are poorly drained. Wireworms require from three to four years to reach their full development, therefore the beet crop following sod may suffer damage over a period of years.

These pests are also difficult to control, but some relief may be obtained by following the methods suggested for white grubs; that is, fall plowing and avoiding planting beets on sod or grasslands. Low, wet, or sour lands should be drained, if possible, as the wireworm that inhabits such types of soil does not thrive in well-drained areas. Clover and buckwheat are not particularly susceptible to damage by wireworms, and these crops may be grown in areas which are heavily infested before the beet crop is planted.

Several kinds of flea beetles may attack the beet in the seedling stage by feeding upon the leaves. Under hot, dry conditions unfavorable to the proper growth of the crop these insects may destroy an entire stand in a comparatively short time. A method of combating these pests consists in rolling the fields during the middle of the day at a time when the flea beetles are most active and while the beets are somewhat wilted. This practice will crush many of the flea beetles and will cause little crop injury. Lime applied directly to the foliage of the plants in liberal quantities will act as a repellent to these pests. However, in order fully to protect the crop by the use of lime or other repellents it is necessary to cover all parts of the foliage, since the insect will seek the untreated portions of the plant for food.

Grasshoppers occasionally do considerable damage to the young crop, but they can be satisfactorily controlled by the use of a poisoned-bran bait. The poisoned bait for grasshoppers contains practically the same materials as that for cutworms and is prepared in like manner. The mash or bait should be scattered over the fields whenever the crop is threatened by a grasshopper attack.

BY-PRODUCTS

There are several by-products of the beet-sugar industry which are distinctly of agricultural significance. The most important of these is the forage supplied by the leaves and crowns that are left on the field when the crop is harvested. (Fig. 23.) Other by-products, such as beet pulp, molasses, and lime cakes, have also considerable agricultural value.⁵

⁵ For further information on beet-top silage and other by-products of the sugar beet, see Farmers' Bulletin 1095, Beet-Top Silage and Other By-products of the Sugar Beet.

The weight of tops and crown produced in a field of sugar beets varies according to the yield of roots obtained. If the tops and crowns are weighed while still fresh it will often be found that the weight is equal to the weight of roots produced, but under certain conditions the weight may not be more than one-fourth of the weight of roots. Much of the weight is lost upon drying, but the dried tops are still palatable feed for cattle. From the ordinary beet crop, therefore, 5 to 8 tons of material suitable for forage can be assumed as an additional return from the beet crop.

The tops are usually utilized by pasturing cattle and sheep upon them in the field, or they may be siloed. If pastured, a considerable portion of the feeding value is lost by the tops being trampled into the ground, but this method of utilization eliminates the cost of



FIGURE 23.—Sugar-beet tops piled and ready to haul to the silo

handling. Since the crown contains salts that are very laxative, it is advisable, when the tops are to be pastured, to limit the time each day that the stock is allowed to feed upon them.

In siloing, whether the tops are to be placed in an ordinary silo or in a rick, it is advisable to mix straw or corn stover with the tops to absorb the excess moisture. If placed in an ordinary silo the mixing should be done as the material is put through the cutter. If the tops are siloed in a rick, they are not put through the cutter, and layers of straw and tops should alternate, each layer being about a foot thick, the whole being covered with a layer of straw upon which some earth is placed.

The feeding value of the beet-top silage, while probably varying considerably, is indicated by the comparison with corn silage shown in Table 3.

TABLE 3.—*Comparative analyses of beet-top and corn silage*¹

Items of comparison	Moisture	Ash ²	Crude protein	Crude fat	Crude fiber	Nitrogen free extract
	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
Beet-top silage ³	64.36	9.25	2.87	0.44	5.46	17.62
Corn-top silage ⁴	68.50	1.51	3.12	.80	6.53	20.54

¹ From U. S. Dept. Agr. Farmers' Bul. 1095, Beet-Top Silage and Other By-products of the Sugar Beet.

² Dirt gathered with the tops makes a high ash content.

³ It is possible that silage produced from beet tops grown in other localities might show a higher or a lower feeding value.

⁴ The analysis here given for corn silage is considerably higher than the generally accepted standard analysis for that product.

The root material from which the sugar has been extracted is known as pulp. This is sometimes placed in large circular silos near the factory, where it goes through fermentation before being sold to the growers. In a few cases it may be sold before fermenting. However, on account of the bulk and low value of the fresh or wet pulp, it is becoming more and more common for the pulp to be dried before being sold. In a good many cases the dried pulp is sold to manufacturers of stock feed instead of to the growers. The composition and feeding value of fresh and dried pulp in comparison with corn stover is given in Table 4.

TABLE 4.—*Composition of fresh and dried beet pulp and final molasses compared with corn stover*¹

Items of comparison	Water	Ash	Crude protein	Crude fiber	Nitrogen free extract	Fat
	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
Corn stover, ears removed.....	9.4	5.8	5.9	30.7	46.6	1.6
Fresh beet pulp.....	90.7	.4	.9	2.1	5.7	.2
Dried beet pulp.....	8.2	3.5	8.9	18.9	59.6	.9
Final beet molasses.....	25.3	5.2	3.5	-----	66.0	-----

¹ Henry and Morrison, Feeds and Feeding, ed. 15, 1915.

The residue from the factory-recovery processes consisting of uncrystallizable sugar and various mineral constituents is called beet molasses. Beet molasses where available can be utilized for cattle feeding.

In the process of extracting the sugar from the sugar beet, a large amount of limestone is used, approximately 6 per cent of the weight of the roots sliced. This lime is finally discharged into settling basins near the factory, where it accumulates. Sometimes it is removed from the basins and heaped up in great piles. It has a considerable agricultural value, as its composition when dry (approximately 82 per cent calcium carbonate) compares very favorably with the ground limestone found on the market. This supply of lime cake, factory lime, or waste lime, as it is variously called, which is available at low cost is an important factor for soil amelioration in a community where soils need correction in reaction or where because of their tendency to become compacted the flocculating influence of lime is of value.

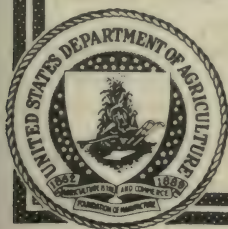
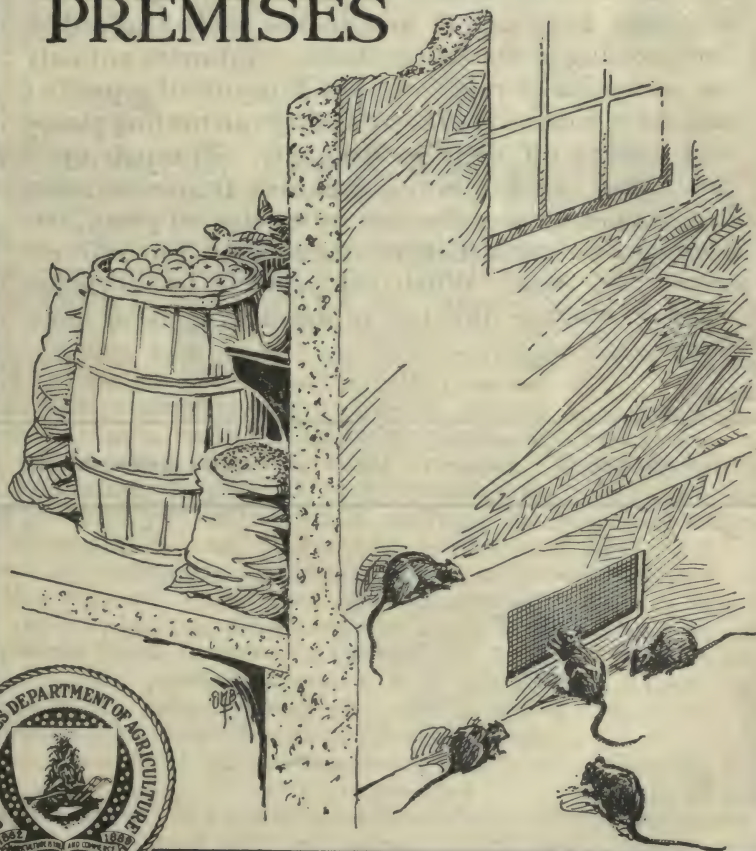
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U. S. DEPARTMENT OF
AGRICULTURE

FARMERS' BULLETIN No. 1638

RAT PROOFING
BUILDINGS *and*
PREMISES



U. S. DEPARTMENT OF AGRICULTURE
FARMERS BULLETIN NO. 1030

FOOD AND SHELTER are as essential to rats as to other animals, and the removal of these offers a practical means of permanent rat control. The number of rats on premises and the extent of their destructiveness are usually in direct proportion to the available food supply and to the shelter afforded. Rat proofing in the broadest sense embraces not only the exclusion of rats from buildings of all types but also the elimination of their hiding and nesting places and cutting off their food supply. Through open doors and in other ways, rats may frequently gain access to structures that are otherwise rat proof, but they can not persist there unless they find safe retreats and food. When rat proofing becomes the regular practice the rat problem will have been largely solved.

Washington, D. C.

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RAT PROOFING BUILDINGS AND PREMISES

By JAMES SILVER, *Associate Biologist*, and W. E. CROUCH, *Senior Biologist*,
Division of Predatory-Animal and Rodent Control, Bureau of Biological
Survey, and M. C. BETTS, *Senior Architect, Division of Agricultural Engi-*
neering, Bureau of Public Roads.

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INTRODUCTION

THE PRINCIPLES of modern construction of buildings are opposed to everything conducive to the best interests of the rat. They call for the liberal use of indestructible and noncombustible materials, as well-made concrete and steel, and these are too much for even the sharpest of rodent incisors. They include, also, fire stopping in double walls and floors and the elimination of all dead spaces and dark corners, and the rat is left no place in which to hide. They embody sanitary features that provide for hygienic storage of food, and the rat can not live without something to eat.

Many men have devoted their lives to a study of methods of rat control, and as a result countless preparations, devices, and contrivances are constantly being made available. Trapping, snaring, trailing, flooding, digging, hunting, ferreting, poisoning, and fumigating are employed, and rat limes, rat lures, rat repellents, and bacterial viruses are resorted to, and even antirat laws, local, State, and national, are constantly being passed in a world-wide effort to conquer this rodent. These have been important factors in keeping down the surplus, but all destructive agencies that have been used have utterly failed to reduce materially the total number of rats in the world. Rat proofing, however, is at last making definite headway against the age-old enemy of mankind, and it is upon this that the ultimate solution of the rat problem will depend.

The destruction of rats for temporary relief and for keeping them under control in places where rat proofing is not possible or practicable will always be necessary, and knowledge of the best means of destroying rats is essential to any rat-control program. Information on poisoning, trapping, and other means of destroying rats is given

in Farmers' Bulletin 1533, Rat Control. Permanent freedom from rats, however, should be the goal of everyone troubled with the pests, and rat proofing offers the best means to this end.

GENERAL PRINCIPLES OF RAT PROOFING

Every separate structure presents its individual problem, but there are two general principles that apply in all cases and that should be kept in mind when the rat proofing of any building is being considered. First, the exterior of those parts of the structure accessible to rats, including porches or other appurtenances, must be constructed of materials resistant to the gnawing of rats, and all openings must be either permanently closed or protected with doors, gratings, or screens; second, the interior of the building must provide no dead spaces, such as double walls, spaces between ceilings and floors, staircases, and boxed-in piping, or any other places where a rat might find safe harborage, unless they are permanently sealed with impervious materials.

All new buildings should be made rat proof. When plans are being drawn for a building, the rat problem is frequently overlooked, usually because rats are not often present near sites selected for new structures. They are certain to come later, however, and should therefore be taken into account. Modern structures are so nearly rat proof that to make them completely so requires only slight and inexpensive changes. Furthermore, rat proofing is closely associated with fire stopping and with sanitary measures that are now required by law in many places. Cities in growing numbers have added rat-proofing clauses to their building ordinances with such good effect that others are sure to follow their lead. Builders should therefore compare the cost of rat proofing during construction with the probable later cost, in case local laws should require that all buildings be made rat proof.

RAT PROOFING FARM BUILDINGS

The cost of rat proofing the entire premises of many American farms would amount to less than the loss occasioned by rats on the same farms during a single year. In no other place is rat proofing more badly needed or less often accomplished than on the farm. There are, however, numerous examples of rat-proof farms in nearly every county in the United States, and almost invariably they are the more prosperous farms, for the rat proofing of a farm is an indication that the farmer has learned the necessity of stopping all small leaks, which mean reduced profits.

A rat-proof farm is not necessarily one in which the entire farmstead is absolutely proofed, but rather one where conditions are so unfavorable for any invading rats that they either will desert the premises of their own accord or may be easily routed by man or dogs. The source of the trouble on almost any heavily rat-infested farm can be traced directly to conditions that furnish rats safe refuges near abundant food. The commoner of these rat-breeding places are beneath wooden floors set a few inches off the ground in poultry houses, barns, stables, granaries, cornercribs, and even residences; in piles of fuel wood, lumber, and refuse; in straw, hay,

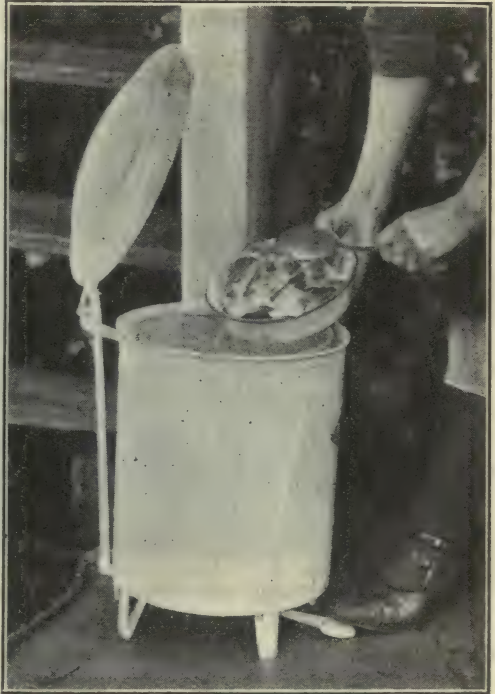
and manure piles that remain undisturbed for long periods; beneath concrete floors without curtain walls; and inside double walls of buildings. In rat proofing the farmstead as a whole, attention should first be paid to the premises outside the buildings and later to each building separately.

Neatness is of prime importance in keeping a place free from rats, and providing facilities for keeping it neat should be considered part of the rat-proofing program. An incinerator, which can be made from a discarded metal drum or rolled-up poultry netting, is convenient for burning all trash and combustible waste; and a deep, covered pit with a trapdoor will take care of tin cans and other noncombustibles, if it is not practicable to haul them away at regular intervals. A covered garbage can is also indispensable on farms where table scraps are not fed directly to poultry or hogs. (Fig. 1.) Raised platforms, 18 or more inches high, should be provided upon which to pile lumber or other materials that if placed on the ground would afford shelter for rats. (Fig. 2.)

Large piles of cut stove wood on many northern farms become rat infested. The same is true of manure piles adjoining barns and, to a lesser extent, of hay and straw stacks near farm buildings. These do not provide food and are attractive to rats for harbors only if near a source of food supply; moving them to a place at some distance from where food-stuffs are handled will usually solve the problem.

Stone walls at times furnish excellent harborage for rats but, like the woodpile, only if there is ample food near by. Stone walls supporting embankments and driveways on sloping farmsteads are most frequently infested, and when this occurs the inviting openings can usually be readily closed with small stones and cement.

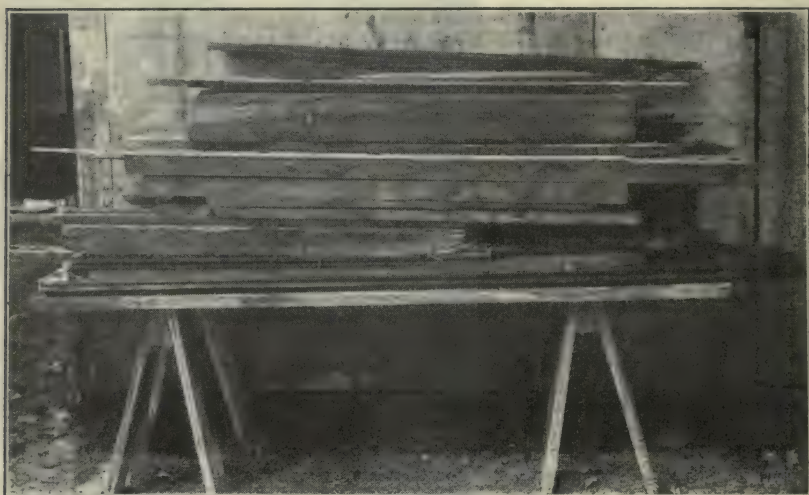
Ditch banks often are a source of rat infestation, but in most climates during the warmer months only. The rodents concentrate in such places because they are less likely to be disturbed there. Rat proofing the ditch bank consists merely of burning or otherwise destroying the protective vegetation. This, of course, affords only temporary relief and should not be considered strictly rat proofing.



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FIGURE 1.—An automatic garbage can, always closed when not in use

The use of concrete in the construction of most farm buildings is usually the best means of permanently excluding the rat. Fortunately, many of the fundamentals of rat proofing are also principles of good construction. As an example, in order to support a building properly, the foundation should extend well into the ground below the frost line; rat proofing likewise requires that the foundation wall extend at least 2 feet below the surface. Rats seldom burrow deeper than 2 feet unless natural passageways assist. Foundation walls should project a foot or more above the ground in order to protect the wooden parts of the building, and this also lessens the opportunity for rats to gnaw through the wall. A rat is not likely to cling to the exposed exterior of a building a foot above the ground while it gnaws a hole through wooden sheathing or siding. It would do so very quickly, however, if such siding extended to the ground,



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FIGURE 2.—Lumber and other stored materials piled well off the ground to prevent rat harborage

where its work could be under cover of vegetation or behind some object, particularly when the siding becomes somewhat rotted, as would soon happen were it close to the ground.

It is important that concrete be hard, as weak concrete is but a slight obstacle to the sharp rodent incisors. The mixture approved for ordinary building construction, however, is sufficiently hard to be entirely rat proof, and it is essential that approved practices of mixing and placing concrete be followed. Directions for using concrete and for building concrete floors are given in Farmers' Bulletin 1279, Plain Concrete for Farm Use, and in Farmers' Bulletin 1480, Small Concrete Construction on the Farm. Other approved building practices, such as fire stopping double walls, eliminating waste dead spaces, making doors, windows, and ventilators fit tightly, and screening or permanently stopping all openings, are also necessary in rat proofing. For simple farm buildings the foundation illustrated in Figure 3 meets all the requirements of good construction and will keep the rats out if the walls are tight.

BARNs

It is seldom possible to shut out rats completely from barns or entirely to cut off their food supply where livestock is fed. Little trouble will be experienced with them, however, if their harbors are eliminated. In barns rat harbors are most frequently found around stalls, under wooden mangers and stall partitions, and beneath wooden or dirt floors. In modern barns with concrete floors, concrete or metal mangers, and metal stanchions, such places of retreat are entirely eliminated. In older barns it is desirable at least to replace wooden and dirt floors with concrete and reconstruct the mangers so that they are a foot or more off the ground.

Another common source of rat trouble, particularly in the northern half of the United States, is the hollow wall, within which rats find safe retreat and convenient runways leading to the haymow. In recent years fibrous insulating materials have been used to line the interiors of many farm buildings, and in most cases these have resulted in greatly increased rat infestation. Rats cut through these composition boards very easily and seem to be attracted by the facilities for breeding thus provided. Hollow walls of any kind accessible to rats should either be eliminated or adequately rat proofed. Such rat proofing may be accomplished by filling the hollow spaces to a height of 8 or 10 inches above the sill with cement, bricks, or other material resistant to the gnawing of rats, or a strip of galvanized metal 2 or more feet wide may be carried around the inside wall just above the sill.

Old barns with wooden floors supported a few inches above the ground on girders and posts are particularly objectionable from the standpoint of rat infestation and should be rat proofed with concrete. (Fig. 4.) A concrete foundation wall extending at least 2 feet below grade is placed under the girder between the posts. The wooden posts may be removed after the wall has hardened, and the spaces left should then be filled in with concrete. A concrete floor is laid, and cement stucco on metal lath is extended up the walls for at least 2 feet, preferably to the level of window sills.

Rock foundations in many old barns offer excellent harborage for rats unless pointed carefully with cement mortar. If possible, the floor should be raised to the level of the sill and the walls plastered to the window-sill level (fig. 5) in such manner as to prevent access by rats to spaces between the studs.

The grain bin and other similar fixtures must always be considered in rat proofing a barn. It is most important that they be so situated

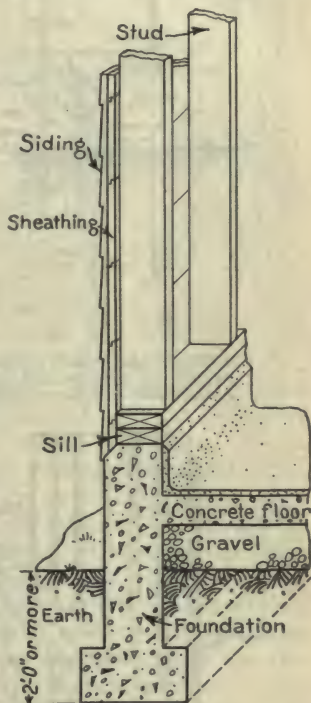


FIGURE 3.—Foundation and floor suitable for most types of farm buildings

or constructed that there shall be no hiding places for rats behind or under them. The grain bin should be completely lined or covered with metal and should have metal-clad lids. Any open spaces behind or under the bins should be tightly closed with metal. (Fig. 6.)

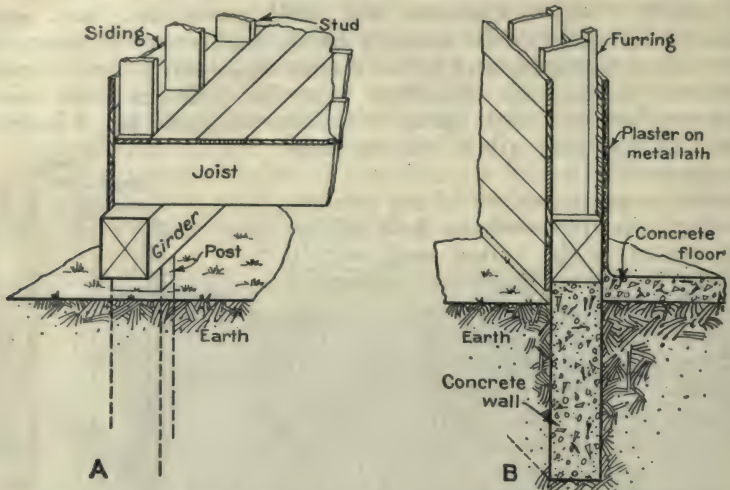


FIGURE 4.—A, Detail of old barn with floor supported a few inches above ground on girders and posts; B, same barn made rat proof with concrete foundation and floors and cement-plastered walls

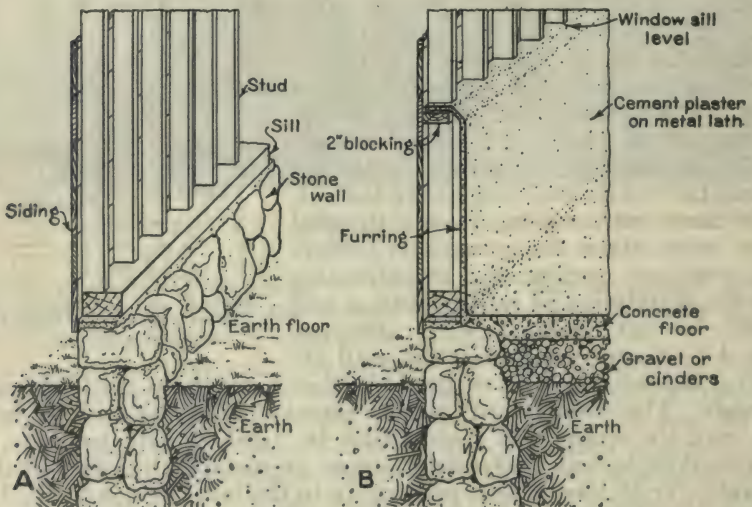


FIGURE 5.—Method of rat proofing old stable, A. Concreting and plastering as shown in B makes for better sanitary conditions behind stock

Other accessories of various kinds of barns should be examined carefully and remodeled or moved if necessary to exclude rats or eliminate harbors. The haymow frequently presents a difficult problem in a heavily infested barn, but the haymow alone is seldom responsible for the rats, for if all other rat harbors in the barn are

effectively eliminated or shut off, the rats will not long remain with the hay as their only shelter. If the lower walls are of rough surface or composed of open studs covered on the outside, rats can climb at the corners. They may be prevented from doing so by the application of a strip of metal 8 inches wide placed just below the joists of the upper floor. Recommended construction of walls and floors in new frame barns is shown in Figure 7.

CORNCRIBS

Of all the buildings on the average farm the cornerrib is usually in greatest need of rat proofing. Losses sometimes amounting to a fourth or a third of the total quantity of corn held over winter have been known. A survey in a southern State showed an average loss

of 5 per cent of corn in storage; in one case 500 bushels were destroyed in one crib during one winter. The amount of this loss would have been sufficient to pay for rat proofing the crib several times over. In building or remodeling a cornerrib, therefore, it is most important that it be made permanently rat proof. Probably the most satisfactory method of accomplishing this with the common slat-sided cornerrib is entirely to cover the walls and ceiling on the inside and the wooden floors on the under side with woven-wire mesh or hardware cloth, two or three meshes to the inch. A heavy grade of woven wire should be used, 12 or 15 gage, and galvanized after weaving. Painting with a tar or asphaltic paint increases its durability.

Another method, and one that is less expensive and quite effective as long as kept in good repair, is shown in Figure 8. Wire netting should be carried around the entire crib to a height of 2 feet or more from the top of the foundation. A strip of galvanized iron 8 inches wide should be fastened above the wire netting. The joints between the foundation and

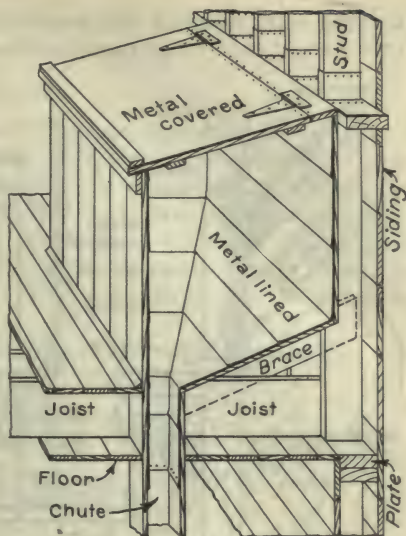


FIGURE 6.—A convenient upper-story rat-proof grain bin

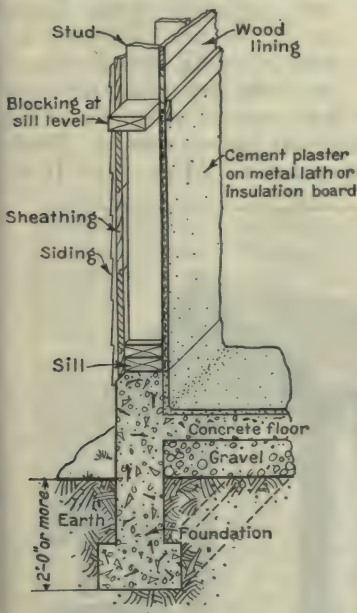


FIGURE 7.—Recommended construction of walls and floors of new frame barns. Cement plaster on metal lath or insulating board is applied to the inside of the studs at least to the level of the window sills as a better protection against rats and as being more easily kept clean than wooden lining

netting and between the netting and metal strip must be tight. As rats are unable to gain a footing on the smooth metal and can not climb over it, it is unnecessary to use wire netting above the strip. Care should be taken to join the lengths of metal tightly and to carry the wire netting and strips of metal across and around both sides of doors and door jams. It is also advisable to provide doors with springs or weights to insure their remaining closed.

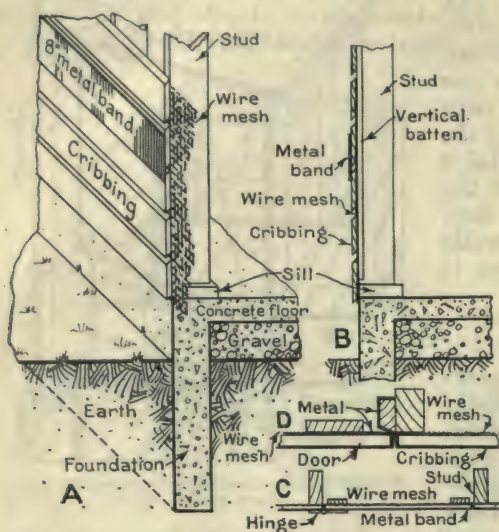


FIGURE 8.—Suggested construction for cornerrib: A, Section through wall; B, section through door, which is made of cribbing on vertical battens; the metal band on the wall extends across the door, but is cut and bent inward at the edges of the door; C, plan of door; D, enlarged detail of jamb at closing side of door

9 inches out from the posts, rats will be kept out of the crib. Old cribs can often be rat proofed in this manner at little expense. Dish pans and washtubs make convenient rat guards. (Fig. 9.) It is



FIGURE 9.—An inexpensive method of rat proofing a cornerrib. It is supported by glazed tiles capped with galvanized washtubs, which, though not attractive in appearance, have successfully kept out rats

important that the area beneath the cornercrib be kept clear and that nothing that the rats can climb be leaned against it.¹

GRANARIES

The rat proofing of granaries is of great importance, because of the abundance of food stored there and the corresponding opportunity for serious loss. The granary with concrete foundation and floors, tight-fitting doors, and screened ventilators presents no unusual problem, except possibly in connection with the elevator pit, which should be carefully checked against possible means of ingress for rats. Small wooden and portable granaries should be protected with wire netting. (Fig. 10.)

Concrete feeding floors, troughs (fig. 11), water tanks, hog wallows, and similar structures should be constructed with a curtain wall, or apron, around the outer edge extending 2 feet or more into the ground (fig. 12) to keep the rats from burrowing underneath the slab. This also tends to prevent the heaving caused by frost and the uneven settling of the structure in soft ground.

POULTRY HOUSES

It is not practicable to attempt to exclude rats from poultry houses, but such buildings can easily be made proof against serious trouble by the elimination of all places where the rodents can obtain safe harborage. Most rat infestation around poultry plants is due to the presence of numerous shelters and suitable breeding places. Three things are particularly to be avoided: Wooden floors on or within a few inches of the ground; double walls; and nest boxes, feed hoppers, and other fixtures placed so as to provide shelter for rats under or behind them. From a rat-proofing standpoint the floors as well as the foundation should be made of concrete. (Fig. 13.) If this is not considered practicable, wooden floors should be elevated so as to insure a clear space of 2 or more feet between the floor and the ground. Warmth can be provided, if necessary, by two thicknesses of flooring with tar paper between. Hollow walls almost invariably furnish harborage for rats. The inner stud covering there-

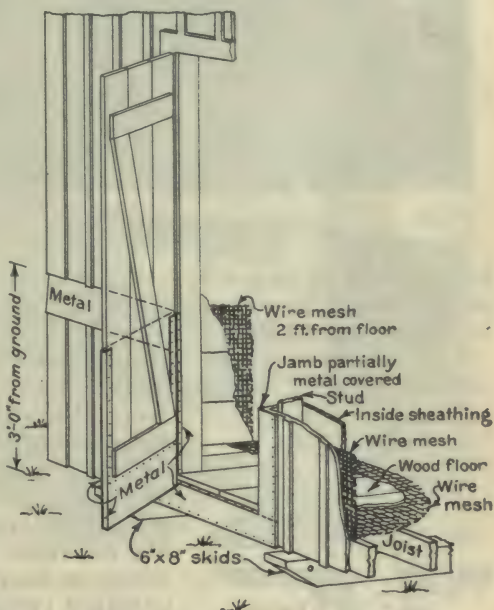
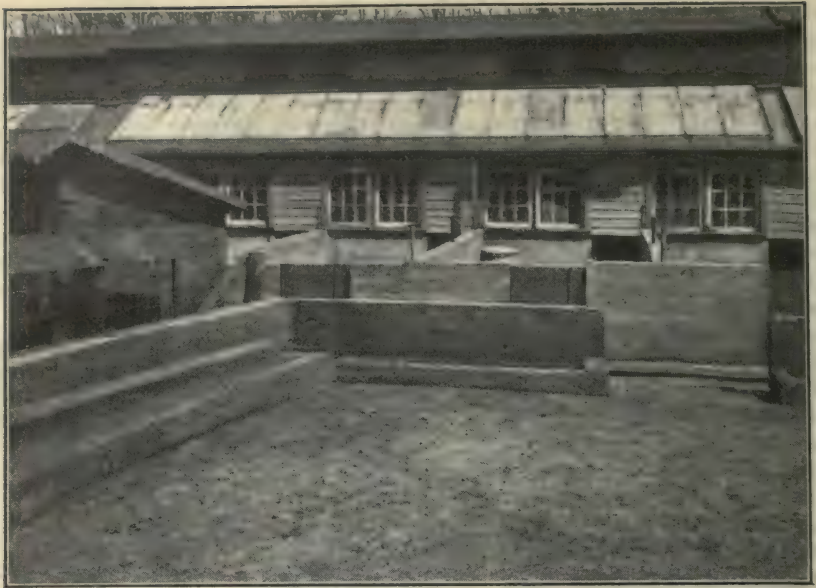


FIGURE 10.—Recommended method of rat proofing a portable granary

¹ Plans for a 2,000-bushel cornercrib (design No. 521) are available upon request addressed to the Bureau of Public Roads, U. S. Department of Agriculture, Washington, D. C.



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FIGURE 11.—Rat-proof pigpens and feeding troughs are easy to keep clean and sanitary, and rats have little opportunity to steal the feed

fore, should be torn out, but if warmth is a factor to be considered, siding should be put over sheathing on the outside of the studs with building paper between.²

Portable laying and brooder houses frequently become heavily infested because they are usually built with wooden floors removed from the ground only by the height of the runners on which they are constructed and are seldom moved as frequently as originally intended. Feed, sifting through the floors, attracts rats, which after finding desirable shelter soon establish themselves in burrows beneath the houses and multiply rapidly. Portable houses, therefore, should be raised off the ground 2 or more feet.

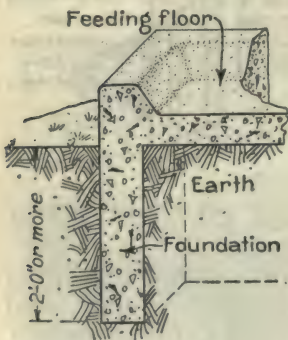


FIGURE 12.—A concrete curtain wall or apron under a feeding floor prevents raveling of earth and consequent breaking of the slab, as well as the harboring of rats

Nests should be raised 2 or more feet above the floor, and feed and grit hoppers at least 1 foot. Drinking vessels for water and skim milk should be supported on a platform 1 to 1½ feet above the floor, so as to eliminate the possibility of rat shelters and keep the liquids in a more sanitary condition. Other equipment should be given the same consideration.

The premises around the poultry house should be cleared of all rat harbors by elevating all objects under which a rat can find shelter. (Fig. 14.) Near-by buildings particularly should be con-

² The construction of poultry houses and fixtures is described in Farmers' Bulletin 1554, Poultry Houses and Fixtures.

sidered, for it is frequently found that rats living exclusively on poultry feed occupy harbors 50 or more feet away from the food source. For this reason it is desirable to build poultry plants at least 100 feet from any possible rat haborage. The vast number of young chicks killed annually by rats would be greatly reduced if these simple precautions were taken.

OTHER FARM STRUCTURES

There are many farm buildings of various kinds that should be made proof against rats. In most cases, however, the application of the general principles of rat proofing, as previously explained, will suffice. Not only should all buildings in which food is kept be

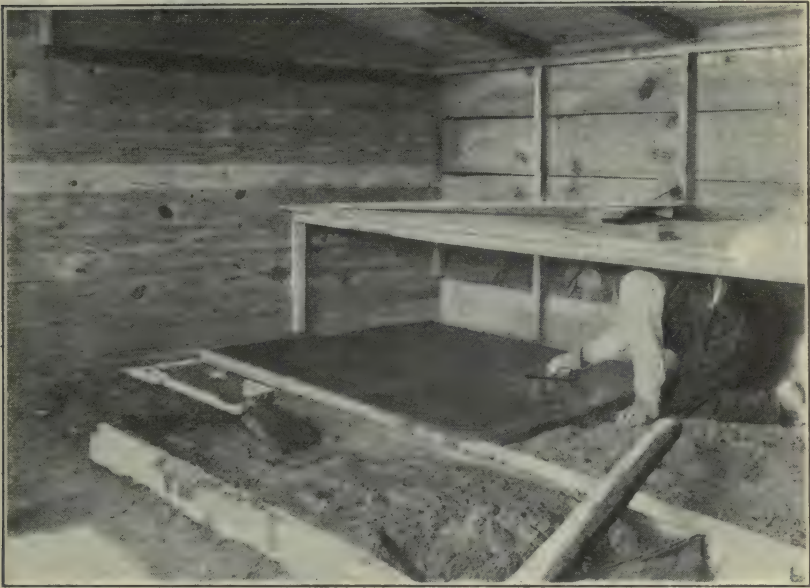
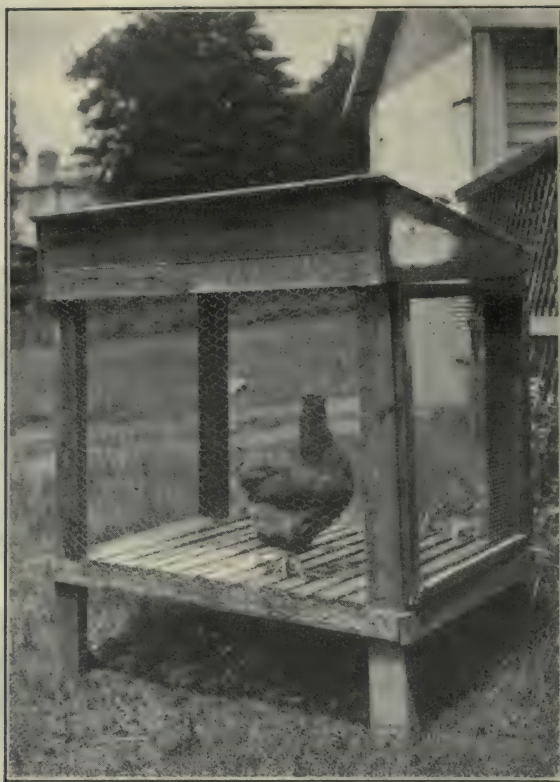


FIGURE 13.—Rat proofing a poultry house by laying a concrete floor

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made inaccessible to rats, but adjoining and near-by buildings and premises as well. The procedure to be followed in the case of farm dwellings is omitted here, as sufficient is included under the next heading, Rat Proofing City Buildings, the conditions with respect to dwellings on farms and in towns being quite similar.

Outside cellars frequently become infested with rats, and great havoc to stored produce almost invariably results. Considerable expense, if necessary, is justified in making the storage cellar rat proof. A cellarway with wooden steps and sills and earth floor is usually the source of the trouble. The sill soon rots or the rats burrow under it to gain entrance. The remedy is to construct a concrete floor and cellarway. This not only will exclude rats but will prove more economical in the long run. (Fig. 15.)



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FIGURE 14.—Coop built up off the ground, rather than with the floor resting on the ground and thereby affording rats a desirable hiding place

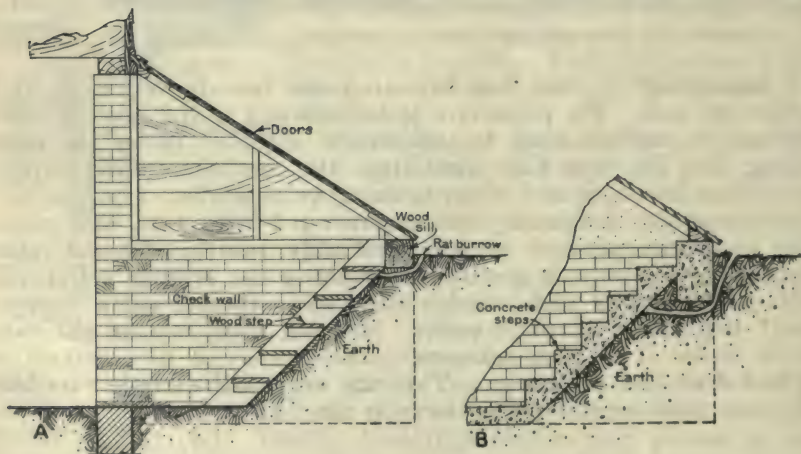


FIGURE 15.—A, Cellarway before rat proofing; B, cellarway rat proofed

RAT PROOFING CITY BUILDINGS

In rat proofing a city building it is well first to look to the exterior. If the locality is heavily infested with rats, some are almost certain sooner or later to find their way into the building however well protected against them it may be. Garbage and trash usually comprise the bulk of the rats' food supply. A metal, water-tight garbage can, large enough to contain all garbage accumulations between collections and having a close-fitting lid (fig 1), is of prime importance and should be required in all cases by city law.

Large accumulations of trash usually contain much waste food (fig. 16) and are certain to attract rats and furnish an ideal breeding place for them. Furthermore, they are a menace to health and

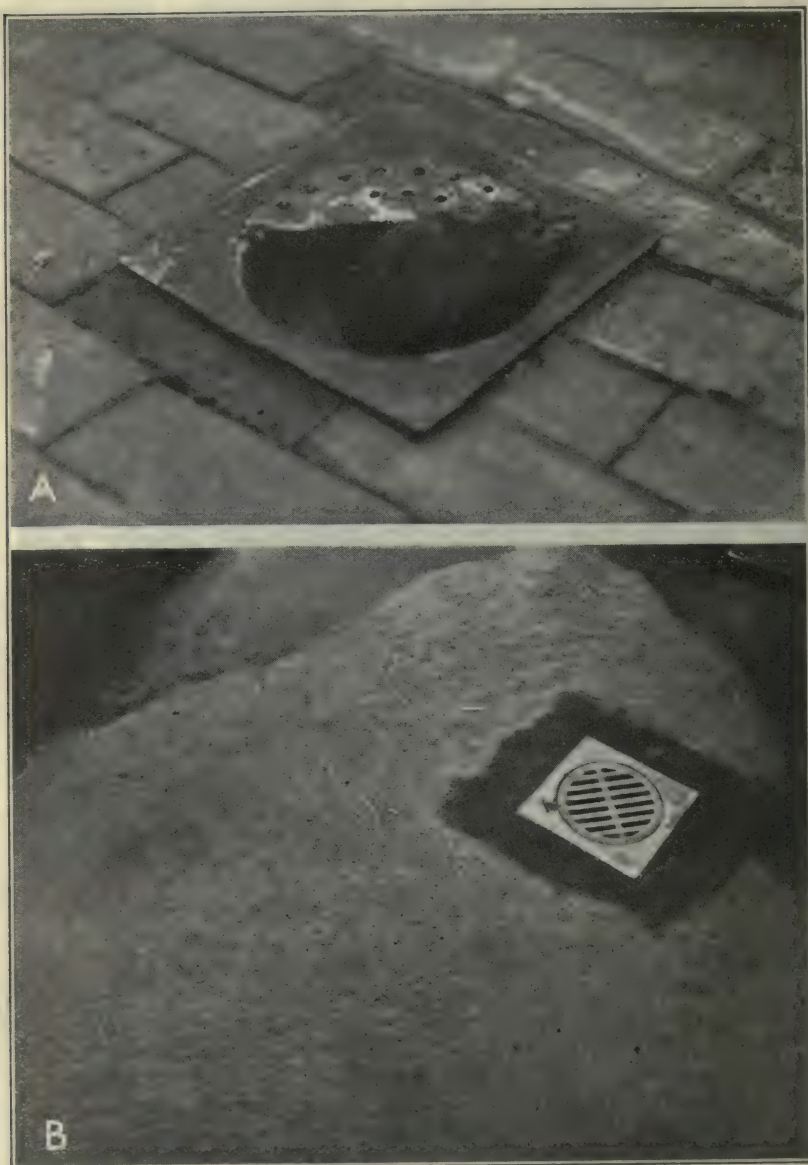


FIGURE 16.—An accumulation of trash such as this is almost certain to attract rats and should be prohibited by law

should not be tolerated under any circumstances. All other rat harbors, such as wooden floors and sidewalks very near the ground, should be removed or replaced with concrete, and piles of lumber and various materials stored out of doors should be removed or elevated 18 or more inches. Particular care should be taken to see that sheds and other outbuildings, porches, steps, loading platforms, and similar structures on the premises are made rat proof, either by the use of concrete, by elevation, or by keeping them open to the light and easily accessible.

A thorough inspection should next be made of the building itself and careful note taken of alterations and repairs necessary for a thorough job of rat proofing. Inspection should begin in the basement. Doors and windows should fit snugly, particularly doors leading to outside stairs or elevators, and these should also be pro-

vided with automatic closing devices. Windows and ventilators should be screened or covered with gratings, the openings not more



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FIGURE 17.—A, Broken floor drains provide a ready means for invasion by rats; B, rat tracks in freshly laid concrete around newly repaired drain show that before repairs were made the drain was a rat highway

than half an inch square. Defects in basement floors should be repaired with concrete, and floor drains should be fitted with tight covers. (Fig. 17.)

Side walls should be carefully inspected, and all openings made for plumbing (fig. 18), electric-wire conduits, areas around windows and doors, and unpainted joints in masonry walls (frequently left

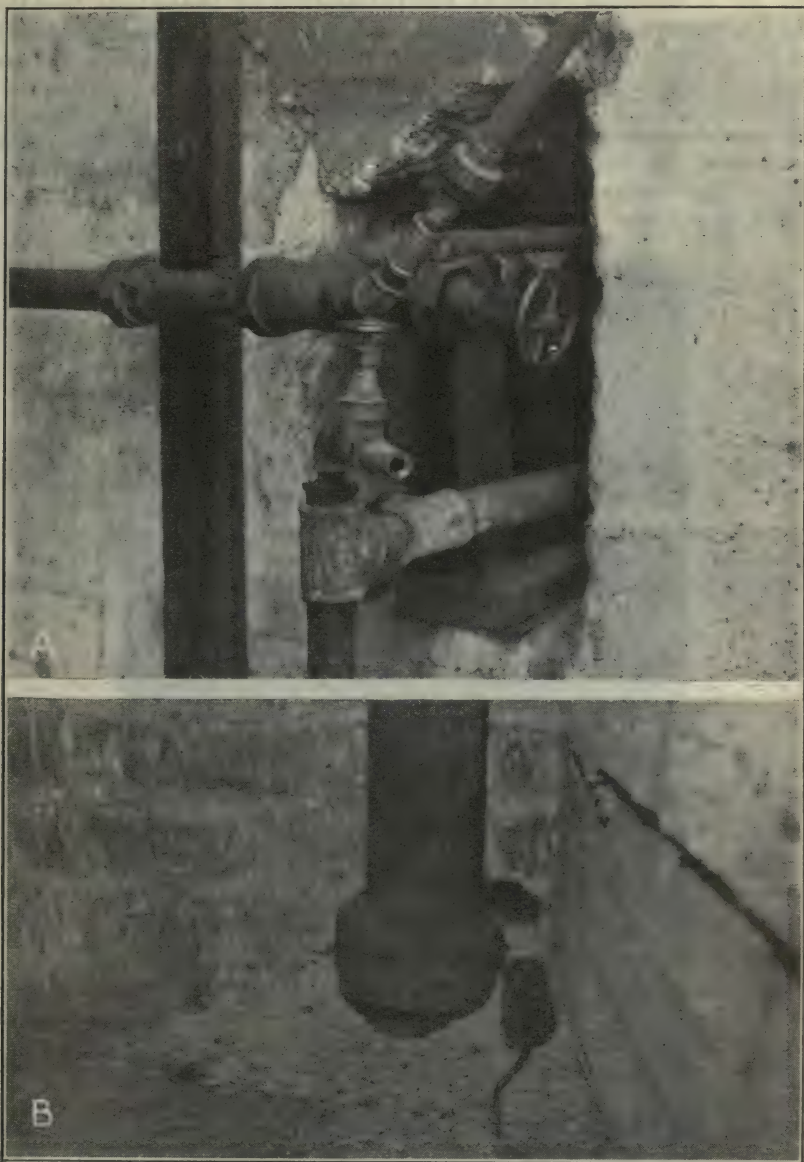
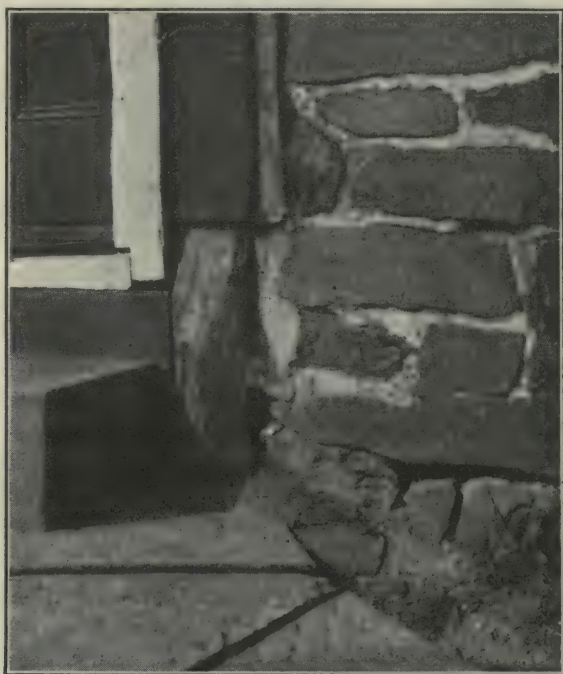


FIGURE 18.—A, Openings around pipes are a common source of rat infestation; B, situations like this give rats access to otherwise rat-proof buildings

when the exterior of the wall is hidden from public view by porches or platforms) should be carefully closed with cement mortar. (Fig. 19.)

Basement ceilings, when accessible to rats, cause much trouble, and frequently the best remedy is to remove them entirely. In frame construction spaces between studs in walls opening into basements also are a common cause of rat infestation of the whole building. The permanent closing of these spaces with noncombustible material not only shuts out the rats but also reduces the fire hazard by stopping the drafts and the rising of heated gases should a fire start in the basement. This process of blocking spaces between studs and furring is commonly known as fire stopping and is of such importance that the building regulations of many cities now require it. Figure 20 illustrates practical methods of rat proofing stud spaces in old buildings.



B4288M

FIGURE 19.—Defects in foundations, such as the opening to the right of the step, are often the cause of rat infestation in old buildings

All openings between floors and in partitions made for the passage of pipes and wires and any defects in the wall should be closed with metal flashing. All dead spaces throughout the building, such as boxed-in plumbing, spaces behind or beneath built-in cabinets, counters, shelving, bins, show windows, and many similar places, should be removed, opened up, or effectively and permanently proofed against rats.

In the Southern States, where the roof rat occurs, similar care must be taken to make the upper floors and roofs of buildings rat proof, as this rat is an expert climber and frequently enters buildings by way of the roof. Doors at the top of stairs and elevators should fit snugly, and all ventilators, exhaust fans, unused chimney flues,

and other openings should be screened. Broken skylights and openings under eaves and places where electric wires enter the building should be repaired or closed.

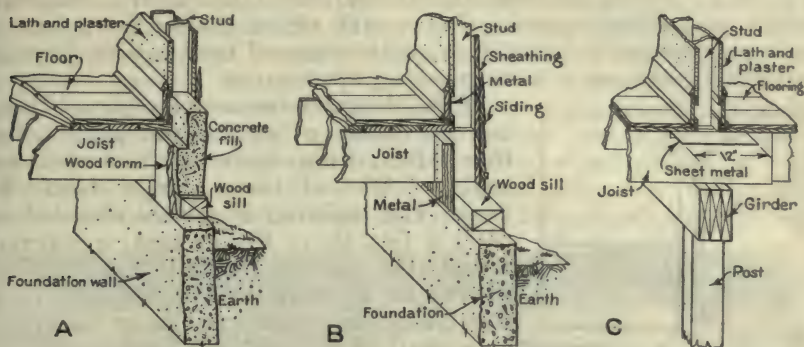


FIGURE 20.—Methods of rat proofing stud spaces in old buildings: A. Construction at outer wall. Open stud spaces are filled with weak concrete, which is placed by removing the skirting above. If the work is done a little at a time, the wooden forms can be removed when the concrete has set, and used again. B. Another method employing sheet metal secured to sill, joist, and flooring. C. Post and girder in basement supporting partition with open stud spaces. Sheet metal nailed to joists and floor and fitted about the stud prevents access to upper floors.

Buildings that have neither basements nor continuous masonry foundations present more difficult rat-proofing problems. The most effective procedure is to construct a concrete foundation wall between the existing supports and, after the wall has hardened, remove the

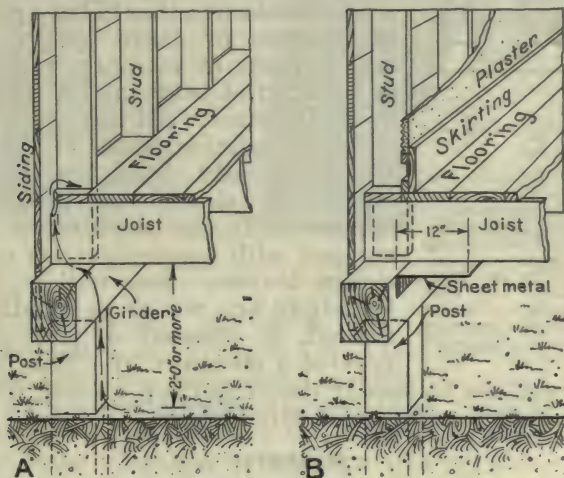


FIGURE 21.—A. Typical construction of frame building on wooden girders and posts with joists more than 2 feet above ground; B. sheet metal placed as shown serves to prevent the rats from climbing to a point where they can gnaw through the wood.

supports, if of wood, and replace them with concrete to make the wall continuous. Where the cost prohibits following this plan and where the supporting sill and joists are at least 2 feet above the ground level, satisfactory rat proofing may be attained by stopping

the spaces between the studs with weak concrete or other material resistant to rats for a distance of 8 inches above the floor level, or with galvanized-metal flashing nailed to the joists, plate, and floor. (Fig. 21.) The space beneath the building must be free from all rubbish and other material that would afford shelter for rats. A continuous masonry foundation, with screened openings to provide ventilation, presents a more pleasing appearance.

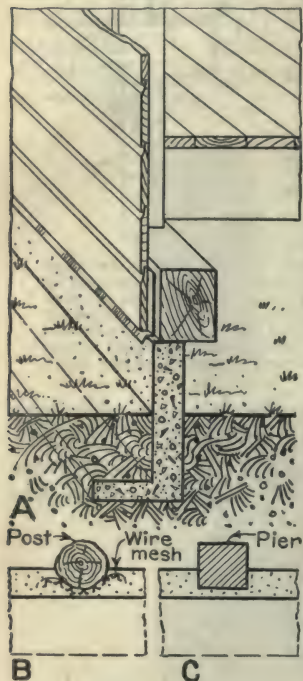


FIGURE 22.—A, Concrete curtain, or area wall, designed for rat-proofing purposes; it does not support the building. B, Plan of wall where supports are of wood; the concrete is bound to the posts with wire mesh. C, Plan of masonry support; concrete will adhere to the masonry if the surface is roughened.

If the clearance between the ground level and the bottom of girders and joists is less than 2 feet, it may provide a hazardous rat harbor. One of three things should be done: The building should be elevated on piers 2 feet above the ground; a concrete foundation should be built as described above; or a continuous concrete curtain wall should be constructed under the entire outer wall of the building. (Fig. 22.)

Most new city buildings are now built practically rat proof, or could be made so with only minor changes in the plans and at small cost. Yet if certain essential details are not included at the start, endless rat troubles are likely to ensue. It is therefore highly desirable that plans for every new building include specifications for rat proofing.

All new buildings in which foodstuffs are to be handled should have ground floors of concrete or other rat-proof material and concrete or masonry walls extending at least 2 feet below and 1 foot above the ground surface. All unnecessary openings in the foundation, walls, and floors should be permanently closed, and windows and ventilators should be screened. Stud spaces in frame construction should be stopped with noncombustible material resistant to rats. New buildings in which foodstuffs are not to be handled may, if desired, be elevated on piers or posts to provide a clearance of 2 feet between the

ground level and the bottom of the supporting girders, although the concrete or masonry wall is more satisfactory.

MARKETS

Public, farmers', and wholesale markets, commission houses, and similar places where vast quantities of foodstuffs are assembled and redistributed are nearly always infested with large numbers of rats. Such structures are usually concentrated in districts, and these often become rat-breeding centers, from which the rats constantly overflow to adjoining sections of the city. Rat proofing a district of this kind would seem to be almost hopeless, yet it has often been demonstrated that the task is not only feasible but entirely practicable. Here, more than anywhere else, the great need is the

elimination of rat shelters, which in turn means the free use of concrete or other masonry. Scrupulous cleanliness is essential in markets, but even where this is practiced it is not possible completely to eliminate rat food, so the main reliance must be placed on the removal of all rat harbors. Not only must the building in which the market is housed be rat proofed, but also all the fixtures. In old public markets the stalls were frequently constructed as if designed for the protection of rats. Dark, out-of-the-way holes under counters, stands, and shelves afford convenient places for the accumulation of trash, which it would be well to destroy; and in such locations, with abundance of food at hand, rats are in the best possible position to thrive and multiply. The use of smooth con-



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FIGURE 23.—Rat-proof market stalls. Rats are unable to climb the smooth tiles to get at foodstuffs left on the counter

crete or tile counters (fig. 23) erected on concrete floors deprive rats of the essential shelter, provided that the space underneath the counter is kept clean and that stored material is moved frequently. The smooth surface also prevents the rats from climbing and makes it possible to leave edible products on the counter overnight without fear of their being damaged or contaminated by the rodents. If wooden floors are used, the boards should be laid flat on the concrete or on sleepers not more than half an inch high.

WAREHOUSES

Warehouses require rat proofing because of the great quantities of foodstuffs handled there and even stored for long periods. It is essential that the building itself be rat proofed with concrete or masonry foundation, concrete floors, and tight-fitting doors lined with metal at the base. Doors of warehouses frequently become

jammed as a result of heavy trucking and should be carefully watched for defects that would admit rats. Concrete floors, in addition to being rat proof and fire proof, save labor because of the comparative ease with which loaded trucks can be rolled over them.

When warehouses are found to be seriously infested with rats, the trouble can usually be traced to such faulty construction as allows the rats access to spaces beneath floors or within walls, or even provides exits to near-by shelter outside.

Rats also gain entrance to rat-proofed warehouses through being shipped in with produce or when doors are left open, and once inside they may persist and do much damage from shelter afforded by piles of stored goods. Such damage, however, is usually small in comparison with that resulting from permanent rat harbors beneath floors, and the rats can be destroyed much more easily. A report from one flour warehouse indicated that it cost more than \$3,000 a year to repair bags gnawed by rats and mice. Such a loss would go far toward rat proofing any premises. A common cause of rat depredations in warehouses is the construction of platforms a few inches off the floor upon which to pile flour and other produce. Such platforms provide permanent shelter for rats and should be eliminated. Boards may be laid flat on the concrete floor with no spaces between them to afford rat harbors; or, if this is not sufficient proof against dampness, the platforms should be raised a foot or more off the floor to admit light. In such a place a rat does not feel safe and will not stay. Bags of flour, grain, and other produce furnish harborage that can not well be avoided, but such goods are usually moved so frequently that rats do not have opportunity to become established among them.

RAT PROOFING THE CITY

Rat proofing the city is a responsibility of the city government. The greatest force that can be exerted to-day toward the permanent suppression of the rat pest is through the passage of practical building ordinances that require the rat proofing of buildings and the adoption of sanitary regulations that will insure clean premises and adequate collection and disposal of garbage. It has been demonstrated that such requirements not only are effective in reducing the numbers of rats to the minimum, but also that they greatly improve health conditions, reduce the fire hazard, and from a purely economic standpoint are profitable. In one city in which rat proofing has been vigorously prosecuted for a number of years and in which more than 80 per cent of the old buildings have been made proof against rats, the sharp decline in the number of fires resulted in a 5 per cent reduction in the fire-insurance rates. More than \$1,000,000 was spent in the same city in rat proofing 10 miles of docks, but even this large expenditure was found to be a profitable investment.

Probably nothing so nearly reflects the sanitary conditions of a city as the number of rats that it harbors, for the rat population is usually in inverse ratio to the degree of sanitation maintained. In 1930 at least 13 cities in this country had rat-proofing laws, and more than 30 others had fire-stopping requirements that are important in rat proofing.

An effective rat-proofing program must be practicable and not too drastic; otherwise it will fail from lack of popular support. Attempts to enforce rat proofing of existing structures would probably not be feasible unless under stress of an outbreak of bubonic plague or other rat-borne disease epidemic. There seems to be no good reason, however, why buildings constructed in the future or remodeled should not be made rat proof under the requirements of building ordinances. Had such ordinances been enacted 50 years ago and rigidly enforced since that time the large majority of buildings to-day would be rat proof, and rats, with their accompanying filth and destructiveness, would have been largely eliminated. There would also be fewer of the unsightly and insanitary shacks now existing in most cities, and the average structure would be of a more desirable type. As modern construction conforms so closely in principle to the requirements of rat proofing, there should be little, if any, opposition among builders to a rat-proofing clause in building ordinances.

In considering the suppression of rats, at the outset city authorities should discard all methods other than those that strike at the source of the trouble. The actual destruction of rats is necessary as a temporary means of stopping their depredations, but modern construction and sanitation are the weapons that must be relied upon to gain permanent relief. In addition to a rat-proofing ordinance, every city should have a law requiring that all garbage wherever accumulated be kept in rat-proof containers or garbage cans until collected or until destroyed by incineration or otherwise disposed of in a manner that would avoid the possibility of its providing food for rats. Containers should have covers not easily removed by dogs and other animals. The city should also enact regulations prohibiting the accumulation of trash, refuse, or waste matter of any kind on either public or private premises, and should provide adequate means for collecting and disposing of all waste.

Consideration should also be given to the sewer system. Although most modern sewers do not offer opportunity for the unrestricted breeding of rats, there are many still in use that furnish harbors for large numbers of these pests in sections of some cities. Of most importance is the corner catch basin, storm sewer, or street-drainage opening, which should be effectively remodeled, if necessary, to provide smooth interior vertical walls with a drop of at least 3 feet; rats are unable to jump 3 feet vertically or to climb smooth surfaces.

Another place that should receive attention is the city dumping ground, which frequently serves as an incubator for rats, and these soon overflow into near-by sections of the city. A study should be made of methods of disposing of waste materials and a system put into effect that will meet the requirements of the city and insure the destruction, removal, or adequate covering of all such food for rats. Any other conditions that may be found favorable for the breeding of rats, whether on public or on private property, should be declared a public nuisance and ordered corrected.

MODEL RAT-PROOFING ORDINANCES

The samples or models of rat-proofing and garbage-removal ordinances here given were prepared by the United States Public Health

Service as a result of its experience in combating bubonic plague in several coastal cities. They have, in substance, been adopted and put into practice by a number of cities and have been found practicable. They should be applicable to any city after necessary allowance and possible changes have been made to conform to local conditions and constitutional considerations.

AN ORDINANCE DEFINING RAT PROOFING OF ALL BUILDINGS³

SECTION 1. *Be it ordained, etc.,* That it shall be unlawful for any person, firm, or corporation hereafter to construct any building, outhouse, or other superstructure, stable, lot, open area, or other premise, sidewalk, street, or alley, or to repair or remodel the same to an extent of ——— per cent of cost of construction within the city of ———, unless the same shall be rat proofed in the manner hereinafter provided for.

SEC. 2. *Be it further ordained, etc.,* That for the purpose of rat proofing all buildings, outhouses, and other superstructures in the city of ———, except stables, shall be divided into two classes, to wit, class A and class B, and the same shall be rat proofed in the manner following, to wit:

Class A.—All buildings, outhouses, and other superstructures of class A shall have floors made of rat-proof material or of concrete, which concrete shall be not less than 3 inches thick, and overlaid with a top dressing of cement, mosaic, tiling, or other impermeable material laid in cement mortar, and such floor shall rest without any intervening space between upon the ground or upon filling of clean earth, sand, cinders, broken stone or brick, gravel, or similar material, which filling shall be free from animal or vegetable substances; said floor shall extend and be hermetically sealed to walls surrounding said floor, which walls shall be made of rat-proof material or of concrete, stone, or brick laid in cement or mortar, and each wall shall be not less than 6 inches thick and shall extend into and below the surface of the surrounding ground at least 2 feet and shall extend not less than 1 foot above the surface of said floor; provided that wooden removable gratings may be laid on such concrete floors in such parts of such buildings, superstructures, and outhouses as are used exclusively as sales departments, provided that wooden flooring may be laid over the concrete wherever the intervening space between such flooring and the concrete shall not exceed one-half inch; provided further that any sleepers that are sunk into the concrete shall be creosoted.

Class B.—All accidental and unnecessary spaces and holes, ventilators, and other openings other than doors and windows in every building, outhouse or other superstructure in the city of ———, shall be closed with cement, mortar, or other material impervious to rats or screened with wire having not more than one-half inch mesh, as the case may require, and all wall spaces shall be closed with cement, mortar, or other material impervious to rats, which closure shall extend the full thickness of the wall and shall extend upward at least twelve inches above the floor level, and the whole in such manner as to prevent the ingress or egress of rats; or the ingress or egress of rats from such double wall or space may be prevented by protecting the junction of said wall with the floor or other wall with metal flashing of galvanized iron of 28 or 30 gauge, provided that where such double wall is open beneath or is in communication with foundations of the house that said opening shall be effectively closed or said junction with foundations flashed with metal as provided above: *Provided,* That in all buildings, outhouses, and other superstructures of class A and in all stables where there are any spaces in walls between the wall proper and the covering on same, or in ceilings between the ceiling and floor, or other ceiling covering above, said spaces shall be eliminated by the removal of said covering, or so closed with cement, mortar or other material impervious to rats as to prevent the ingress or egress of rats: *Provided,* That all such wall spaces shall be closed with cement, mortar, or other material impervious to rats, which closure shall extend the full thickness of the wall and shall extend upward at least twelve inches above the floor level.

The cellar of every building hereafter erected within the building limits shall be made rat proof by the use of masonry or metal. All openings in

³ U. S. Pub. Health Serv. Bul. 121, Preliminary Report on Proposed Antiplague Measures in Massachusetts.

foundations, cellars and basements in such buildings, except for doors and hatchways, and except also for such windows wholly above ground as may be exempted by the ——— in his discretion, shall be completely covered with screens of metal having meshes of not more than one-half of an inch in least dimension and constructed of rods or wire of not less than twelve gauge.

All buildings, outhouses, and other superstructures of class B separated from any other building on three sides by at least ten feet and lacking any basement or cellar may be rat proofed in the following manner, to wit: Said building, outhouse, or other superstructure shall be set upon pillars or underpinning of concrete, stone, or brick laid in cement mortar, or may be set upon underpinning of substantial timber, such pillars or underpinning to be not less than eighteen inches high, the height to be measured from the ground level to the top of said pillars or underpinning; and the intervening space between said building and the ground level to be open on three sides and to be free from all rubbish and other rat harboring material, or may be made rat proof by constructing at the margin of the ground area of said building a wall of concrete or brick or stone laid in cement; such wall to extend into and below the surface of the ground at least two feet and to meet the floor of the building above closely and without any intervening space, to be at least four inches thick and extend entirely around said building: *Provided*, That said walls may be built with openings therein for ventilation only: *And provided further*, That such openings for ventilation may be all of such size as the owner may elect and shall be securely screened with metallic gratings having openings between the bars of said gratings of not more than one-half inch or with wire mesh of not less than twelve gauge, having openings between the wires of said mesh of not more than one-half inch and the whole so constructed and closed as to prevent the entrance of rats beneath such building.

Sec. 3. *Be it further ordained, etc.*, That every restaurant kitchen, hotel kitchen, cabaret kitchen, dairy, dairy depot, dock, wharf, pier, elevator, store, manufactory, and every other building, outhouse, or superstructure wherein or whereon foodstuffs are stored, kept, handled, sold, held, or offered for sale, manufactured, prepared for market or for sale, except stables, shall be rat proofed in the manner provided for hereinabove as class A: *Provided*, That such part of any structure hereinabove defined as of class A that shall be entirely over a body of water may be rat proofed as of class B, as hereinafter provided for.

"Foodstuffs," as used in this ordinance, is hereby defined to be flour and flour products, animals and animal products, produce, groceries, cereals, grain, and the products of cereals and grain, poultry and its products, game, birds, fish, vegetables, fruit, milk, cream, and products from milk or cream, ice cream, hides, and tallow, or any combination of any one or more of the foregoing.

All other buildings, outhouses, and superstructures, except stables, not hereinbefore specified as class A, and all buildings used exclusively for residential purposes, shall be rat proofed in the manner provided for hereinabove as class B: *Provided*, That the owner of any building, residence, outhouse, or other superstructure in class B may, if he so elects, rat proof same in the manner provided for in class A.

Provided, That in any case where, under the foregoing provisions, any building, outhouse, or superstructure is required to be rat proofed as of class A and the said building or outhouse or superstructure is used in part for residential purposes, and the part used as a residence is effectively separated from the part falling within class A, by permanently and effectively closing all openings above and below the ground floor, or by constructing a new wall, and in either case the whole in such manner as to make such wall whole and continuous in its entirety, without doorways, windows, or other openings between the part used as a residence and that used for such purposes as makes it fall within class A, then in such case and for rat-proofing purposes only, the said building will, after such separation and closure of the openings, or by the construction of such new wall, be deemed to be two buildings; and that part used exclusively for residential purposes may be rat proofed in the manner provided for as a class B building, and the remaining part of said building shall be rat proofed in the manner provided for a class A building.

Stables.—Stables and all buildings hereafter to be constructed and used for stabling horses, mules, cows, and other animals shall be constructed as follows:

Walls: The walls of such buildings shall be constructed of concrete, brick, or stone, laid in cement mortar, and shall be not less than four inches thick, and shall extend into and below the surface of the surrounding ground not

less than two feet, and shall extend above the ground sufficient height as to be not less than one foot above the floor level. All openings in such foundation walls shall be covered with metal grating having openings not greater than one-half inch between the gratings.

Floors: The floors of stables and stalls shall be of concrete not less than three inches thick, upon which shall be laid a dressing not less than one-half inch thick of cement or stone, laid in cement mortar, or shall be constructed of floated concrete not less than four inches thick, in such way as to prevent ingress or egress of rats, and such floors to have a slope of one-eighth inch per foot to the gutter drain hereinafter provided for.

Stalls: The floors of stalls may be of planking, fitting either tightly to the concrete floor or elevated not more than one-half inch from the stall floor, and so constructed as to be easily removable. Such removable planking shall be raised at least once a week, and the said planking and the concrete floor beneath thoroughly cleansed.

Gutters: Semicircular or V-shaped gutters shall be constructed in such manner that a gutter shall be placed so as to receive all liquid matter from each stall, and each of these gutters to connect with the public sewer or with a main gutter of the same construction, which in turn shall be connected with the public sewer or public drain. All openings from drains into sewers shall be protected by a metal grating having openings not more than one-half inch between the gratings.

Mangers: Each manger shall be constructed so as to have a slope of two inches toward the bottom, shall be covered with tin or zinc, and shall be at least eighteen inches deep, to avoid spilling of food.

Feed bins: All feed bins shall be constructed of cement, stone, metal, or wood, and with close-fitting doors. If constructed of wood, the bins shall be lined or covered with metal, and the whole so constructed as to prevent the ingress or egress of rats. All grain, malt, and other animal food, except hay, stored or kept in any stable, must be kept in such feed bins. Said feed bins must be kept closed at all times, except when momentarily opened, to take food therefrom or when same are being filled. No feed shall be scattered about such bin or stable, and all such feed found on the floor or in the stalls of said stables shall be removed daily and placed in the manure pits. No food-stuffs intended for or susceptible of human consumption shall be kept or stored in any stable or any other place where animals are kept.

SEC. 4. *Be it further ordained, etc.* That the construction and materials used in rat proofing shall conform to the building ordinances of the city of ———, except and only in so far as the same may be modified herein.

SEC. 5. *Be it further ordained, etc.* That all premises, improved and unimproved, and all open lots, areas, streets, sidewalks, and alleys in the city of ——— shall be kept clean and free from all rubbish and similar loose material that might serve as a harborage for rats; and all lumber, boxes, barrels, loose iron, and similar material that may be permitted to remain thereon and that may be used as a harborage by rats shall be placed on supports and elevated not less than two feet from the ground, with a clear intervening space beneath, to prevent the harboring of rats.

SEC. 6. *Be it further ordained, etc.* That all planking and plank walks on and in yards, alleys, alleyways, streets, sidewalks, or other open areas shall be removed and replaced with concrete, brick, or stone, laid in cement, gravel, or cinders, or the ground left bare.

SEC. 7. *Be it further ordained, etc.* That it shall be the duty of every owner, agent, and occupant of each building, outhouse, and other superstructure, stable, lot, open area, and other premises, sidewalk, street, and alley in the city of ——— to comply with all the provisions of this ordinance.

SEC. 8. *Be it further ordained, etc.* That it is hereby made the duty of ———, and particularly through its health department, to enforce the provisions of this ordinance.

SEC. 9. *Be it further ordained, etc.* That any law or ordinance in conflict with the provisions of this ordinance be, and the same is hereby, repealed.

AN ORDINANCE REGULATING THE REMOVAL OF GARBAGE

SECTION 1. *Be it ordained by ——— of the city of ———.* That from and after the promulgation of this ordinance, the owner, agent, and occupant of every premise, improved or unimproved, in the city of ———, whereon or wherein garbage shall be created, shall provide a metal, water-tight container

or containers, each with a tight-fitting cover, such container or containers to be of such size as to be easily manhandled, and of such number as to receive the garbage accumulation of five days from each such premise, and shall place or cause to be placed such container or containers, for the purpose of having their contents removed, on the sidewalks or open alleys in front or rear of said premises, at the times hereinafter set forth.

SEC. 2. *Be it further ordained, etc.,* That for the purposes of this ordinance, the city of ——— is hereby divided into ——— garbage districts.

SEC. 3. *Be it further ordained, etc.,* That for the purpose of this ordinance, the word "garbage" as used in this ordinance shall be construed to mean house and kitchen offal, and all refuse matter not excrementitious liquid, and composed of animal or vegetable substances, including dead animals (except cows, horses, mules, and goats) coming from public and private premises of the city, and not destined for consumption as food.

SEC. 4. *Be it further ordained, etc.,* That it shall be unlawful for such owner, agent, or occupant of any such premise to have, maintain, or keep any garbage on any premise except in such garbage containers as are provided for in section 1 of this ordinance.

SEC. 5. *Be it further ordained, etc.,* That such garbage containers shall be kept tightly covered at all times, except when momentarily open to receive the garbage or to have the contents therefrom removed, as provided for hereinafter.

SEC. 6. *Be it further ordained, etc.,* That when such garbage container is placed on the outside of any premise it shall be unlawful for any person engaged in the removal of garbage, or for any person to remove the cover from such garbage container, except for the purpose of emptying its contents into a duly authorized garbage wagon or to throw such garbage container on the street or sidewalk, or to injure it in any way, so as to make it leak or to bend it or its cover, as to prevent said garbage container from being tightly covered; and all persons engaged in the removal of garbage shall, after emptying said container, replace the cover tightly on said container.

SEC. 7. *Be it further ordained, etc.,* That the owner, agent, or occupant of every premise in the city of ——— shall keep separate from their garbage and ashes, tin cans, broken crockery, hardware, old planks, wooden matter, paper, sweepings and other trash, and place same in a sound, substantial vessel or container kept for that purpose, which vessel or container shall be placed on the sidewalk or alley in front or rear of each premise of the city of ———, as provided in section 1 of this ordinance, for garbage containers, for removal on ———, provided that such rubbish, other than garbage, may be so placed on ———.

SEC. 8. *Be it further ordained, etc.,* That the provisions of this ordinance shall apply to all public and private markets, as well as all places of business, hotels, restaurants, and all other premises, whether used for business, boarding, or residential purposes.

SEC. 9. *Be it further ordained, etc.,* That for the purpose of enforcing this ordinance any person living on any premise shall be deemed an occupant, and any person receiving the rent, in whole or in part, of any premise, shall be deemed an agent; that on any premise where construction of any kind is in progress, and where employees or workmen eat their dinners, or lunches, in or about said premises, or scatter lunch or food in or about such premises, the contractor or foreman or other person in charge of such workmen shall be deemed an occupant; and that the person in charge of any market, or stall in any market, shall be deemed an occupant.

SEC. 10. *Be it further ordained, etc.,* That it shall be unlawful for any person to pick from or disturb the contents of any garbage containers or vessels, or other containers provided for in this ordinance.

SEC. 11. *Be it further ordained, etc.,* That each day's violation of any of the provisions of this ordinance shall constitute a separate and distinct offense.

SEC. 12. *Be it further ordained, etc.,* That any person violating any provision of this ordinance shall, on conviction, be punished by a fine of not less than ten (\$10.00) dollars nor more than twenty-five (\$25.00) dollars, or in default of the payment of said fine by imprisonment ——— for not less than ten (10) days nor more than thirty (30) days, or both, at the discretion of ——— having jurisdiction of the same.

SEC. 13. *Be it further ordained, etc.,* That any law or ordinance in conflict with the provisions of this ordinance, in whole or in part, be and the same is hereby repealed.

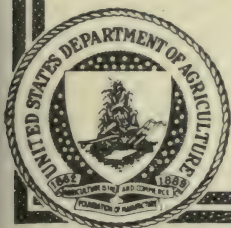
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U. S. DEPARTMENT OF
AGRICULTURE

FARMERS' BULLETIN No. 1639

POTATO PRODUCTION
IN THE
FAR WESTERN
STATES



POTATO GROWING in the Western States differs in some respects from that of other geographical areas and therefore demands a separate treatment. Irrigation plays an important part in the production of potatoes in the far West.

The rapid rise of potato production in Idaho and the wide distribution of the crop of this State is attracting considerable interest on the part of eastern potato growers. Wide distribution has been made possible by growing and putting up a high-quality product.

Large yields on most irrigated lands are possible without the use of commercial fertilizers, provided proper crop rotations are followed.

This bulletin supersedes Farmers' Bulletin No. 953, Potato Culture Under Irrigation.

POTATO PRODUCTION IN THE FAR WESTERN STATES

By WILLIAM STUART, *Senior Horticulturist, Office of Horticultural Crops and Diseases, Bureau of Plant Industry*

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INTRODUCTION

THE INCREASING demand for specific information concerning the production of potatoes in certain sections of the United States necessitates the treatment of the subject on a regional rather than a national basis. The term "Far Western States" as employed in this bulletin refers to Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

During the 5-year period from 1925 to 1929, inclusive, the average annual potato acreage of these 11 Western States was approximately 12.5 per cent of the total potato acreage of the United States, and the potato production of these States was about 16.5 per cent of the country's total. In point of production the individual States of this group rank as follows: Idaho, Colorado, Washington, California, Oregon, Montana, Utah, Wyoming, Nevada, Arizona, and New Mexico.

One of the distinctive peculiarities of potato production in these Western States is that a considerable acreage is under irrigation. Census figures for 1919 show that the irrigated acreage was approximately 10.3 per cent of the total potato acreage of those States. Colorado had the greatest potato acreage under irrigation, with Idaho second, and California third. Utah had the highest percentage of its potato acreage under irrigation, with Idaho, Colorado, and Nevada following in the order mentioned.

Commercial fertilizers are not generally used in potato production in the States named. The only outstanding exception to this state-

ment is in the Stockton district of California, where it has been found highly beneficial to apply large quantities of phosphorus and potash to the potato crop grown on peat soils. With this exception and possibly others where potatoes are grown on peat lands, the growers rely on the natural supply of phosphorus and potash in the soil and the nitrogen derived from turning under alfalfa, sweetclover or other leguminous crops. In this respect considerable expense for fertilizers is avoided by the western potato grower. That it is possible to maintain the fertility of the soil, especially to supply nitrogen through judicious crop rotation, has been amply demonstrated.

CROP ROTATION

While there are no general hard and fast rules relative to length of rotation with other crops, it is a rather common practice to keep the land in alfalfa, in the irrigated sections at least, for from five to seven years. Many growers employing the longer rotation grow two and occasionally three crops of potatoes before seeding the land back to alfalfa.

At the Colorado Potato Experiment Station, located at Greeley, Colo., and operated by the United States Department of Agriculture, a 4-year crop-rotation system was begun in 1915 and continued over a period of 10 years with extremely satisfactory results. The rotation in this case consisted of a crop of potatoes on alfalfa sod, followed the next season with a light seeding of oats and the ordinary seeding of alfalfa, and then by two full seasons in alfalfa. At the close of the 10-year period, when it became necessary to transfer the work to another farm, the fertility of the land and its mechanical condition had been so materially improved as to make possible the production of a large crop of potatoes.

This experience seems to justify the assumption that on small farms it is possible to practice a 4-year rotation, with alfalfa for the soil improver and the potato as a cash crop, with excellent results.

Very satisfactory results may also be obtained when sweetclover is used in the rotation. By using this crop as a soil builder it would be possible to adopt a 3-year crop rotation.

In nonirrigated sections where the rainfall is insufficient or does not come at the proper time of year it is not possible to use leguminous crops in the rotation system. For example, in the Palouse country of northern Idaho and northeastern Washington the potato crop either follows a winter wheat crop or is planted on fallowed land. In the humid portions of western Washington, Oregon, and to a lesser extent California, a greater diversity of crop rotation systems is possible.

SUITABLE SOILS

The potato is probably as cosmopolitan in regard to soil requirements as any of our agricultural food crops. However, like any other crop, it succeeds best on certain types of soil, as, for example, a sandy or gravelly loam soil or a peat or muck soil. Fairly good crops may be produced on black loam or clay loam soils, and indifferent results may always be expected if an attempt is made to produce a potato crop on light shifting sand or heavy clay soils. Poorly

drained soils or those with an impervious subsoil, provided there is little depth of surface soil, should always be avoided.

PREPARATION OF THE SOIL

If best results are to be obtained, the preparation of the land intended for growing potatoes should begin several years before the crop is to be planted. This is particularly true in the geographical area under consideration, because greater reliance than in other regions must be placed on leguminous crops, such as have been mentioned under "Crop Rotation," in maintaining the nitrogen and organic content of the soil, on both irrigated and nonirrigated land.

The proper preparation of the land involves deep plowing and thorough pulverization of the soil prior to planting the crop. It is impossible to produce maximum yields from poorly prepared land. Whether the land should be plowed in the fall or in the spring is largely determined by the physical character of the soil, its exposure, and the previous crop grown. If the soil is inclined to be heavy, it would be benefited by being exposed to the action of frost, snow, and rain during fall and winter. On the other hand, if the exposure or lay of the land is such as to render it liable to undue erosion during the winter, it would be better to plow it in the spring. Some late-crop growers prefer to delay plowing alfalfa sod in the spring until it has made a considerable growth, and then it is plowed to a depth of from 9 to 11 inches. When so handled there is little trouble from surviving alfalfa plants. In plowing alfalfa sod in the fall it is a rather common practice to crown the land; that is, to plow it to a depth of 2 to 4 inches, or just deep enough to cut off the crowns of the alfalfa plants. When this is followed by one or two diskings most of the plants are killed. Fields receiving such treatment are plowed deeply in the spring.

VARIETIES GROWN

The following list of potato varieties, which is submitted for each State, is believed to include most of those that are more generally grown commercially.

Arizona.—Triumph, Early Rose, Burpee Extra Early.

California.—Burbank, Russet Burbank, White Rose, American Giant (Pride, or Wisconsin Pride), Up-to-Date (British Queen), Charles Downing (Idaho Rural), and Garnet Chili.

Colorado.—Rural New Yorker No. 2 (Rural), Russet Burbank, Prolific (Brown Beauty), Charles Downing (Idaho Rural), Peerless (Pearl), Adirondack (Perfect Peachblow, Red McClure), Early Ohio, Irish Cobbler, Triumph, People's.

Idaho.—Charles Downing (Idaho Rural, or Rural), Russet Burbank, Early Ohio, Triumph, People's.

Montana.—Russet Burbank, Triumph, Charles Downing (Idaho Rural, or Rural), Green Mountain, and Early Ohio.

Nevada.—Russet Burbank, Burbank, Charles Downing (Idaho Rural), Peerless (Pearl), and Early Ohio.

New Mexico.—Irish Cobbler, Green Mountain, Russet Burbank.

Oregon.—Burbank, Russet Burbank, Pride of Multnomah, White Rose, Early Ohio, Charles Downing (Earliest of All, Idaho Rural).

Utah.—Rural New Yorker No. 2, Russet Burbank, Early Ohio, Irish Cobbler, Charles Downing (Idaho Rural), Green Mountain, Triumph, and Peerless (Pearl).

Washington.—Burbank, Russet Burbank, Charles Downing (Idaho Rural, Earliest of All), Rural New Yorker No. 2.

Wyoming.—Russet Burbank, Triumph, Charles Downing (Idaho Rural), Peerless (Pearl), and Spaulding Rose (Spaulding No. 4, Rose No. 4, King).

SEED

IMPORTANCE OF GOOD SEED

So much has been said and published during the last few years regarding good seed that further statements on the subject seem unnecessary. However, each year presents overwhelming evidence of the failure of many growers to grasp the fact that without the use of good seed it is impossible to produce large yields. As a result of the seed-potato certification agencies that have been established in practically all of the States under discussion, it is now possible for those who desire to plant good seed to procure it either through the seed-certification agencies or from individuals whose seed has been certified. There is, therefore, little excuse at the present time for any grower using poor seed. The title-page illustrates choice seed stock.

SEED TREATMENT WITH DISINFECTANTS

The value of the treatment of seed potatoes with disinfectants is still questioned in some sections. This is largely due to the fact that where soils are heavily infected with common scab or *Rhizoctonia* organisms there is little apparent benefit from seed disinfection. As a rule, however, it pays to treat seed potatoes before planting them. The effectiveness of the treatment is largely dependent on how closely the operator follows instructions with the disinfectant employed, and the maintenance of strength of the solution if the corrosive-sublimate treatment is used. Seed treatment should be regarded in the nature of a safeguard or insurance against surface-borne tuber diseases. The virus diseases are in nowise affected by seed treatment.

The two standard materials in use as seed-potato disinfectants are corrosive sublimate (mercuric chloride) and formaldehyde, but in the last few years several organic mercury compounds bearing trade names have been widely heralded by the manufacturers as being more easily and quickly applied. Inoculated flowers of sulphur broadcast at the rate of 200 to 300 or more pounds per acre and well worked into the soil has proved highly efficacious in the control of scab on some types of soil and apparently totally ineffective on others.

The standard solutions and time of treatment in the case of corrosive sublimate and formaldehyde are as follows:

COLD TREATMENT

Corrosive sublimate.¹—Four ounces of corrosive sublimate (mercuric chloride, HgCl_2); 30 gallons of water. Soak potatoes one-half to one and one-half hours² in the solution. (Fig. 1.)

Formaldehyde.—One pint of formalin (40 per cent solution of formaldehyde gas); 30 gallons of water. Soak as above.³

¹ Corrosive sublimate is a deadly poison, and every precaution should be observed in its use. It also has a great affinity for metals. It should never be put into metal containers unless they are covered with a coating of asphaltum or other protective material.

² The length of treatment should be governed by the condition of the seed stock. If the seed is moderately infected with either common scab or *Rhizoctonia*, give it the longer treatment. If it is badly germinated, the treatment should be shortened to avoid injury to sprouts or eyes.

HOT TREATMENT

Use 2 pints of formalin and 30 gallons of water. Immerse tubers in hot solution (125° F.) for three to four minutes.

The hot formaldehyde treatment has become sufficiently popular in some sections to make possible community equipment of sufficient capacity to treat large quantities of seed stock. Where such practice prevails, the seed is usually treated in sacks and is allowed to dry in them. When the seed is badly infected, especially with *Rhizoctonia*, it is a good plan to cover the sacks with burlap or heavy blankets for an hour on removal from the hot solution in order to prolong the effect of the treatment. The seed is usually treated before cutting it.

In the case of home treatment of seed, by either the hot or the cold method, the open slat crate makes a good container. It is easily



FIGURE 1.—A large tank for the treatment of seed potatoes. The sacks are lifted into and out of the tank by means of a pulley block and rope tackle

handled and allows the treated seed to dry almost as quickly as if spread out on a canvas. The crate also has another advantage in that the seed can be held in it until cut and planted, thus guarding against the possibility of reinfection by coming in contact with contaminated containers or soil if spread out to dry.

Figures 2 and 3 illustrate the ingenuity of a firm of potato growers in the Stockton district in the construction and operation of a large-capacity hot-formaldehyde treating plant mounted on a barge which is moved about from camp to camp by a small launch.

CUTTING THE SEED

In cutting seed potatoes it should be borne in mind that a good-sized seed piece has a much better chance to grow under unfavorable soil or temperature conditions than small-sized ones. (Fig. 4.) Small whole seed may be used if produced by healthy plants.



FIGURE 2.—General view of a hot-formaldehyde seed-treatment outfit mounted on a barge and towed from camp to camp in the Stockton, Calif., district



FIGURE 3.—The seed-treatment equipment in operation (Stockton, Calif.). Note emergence of sacks at opposite end

Numerous mechanical devices for cutting seed potatoes have been evolved and patented from time to time. Some of them are designed for hand and others for power operation. While such implements reduce the time element to a minimum, they are nevertheless mechanical, and consequently a small percentage of no-eye seed pieces may be expected. There is no satisfactory substitute for careful hand cutting of seed potatoes. The efficiency and the output of the individual may be materially increased by the use of the cutting box and a rigidly-fixed knife blade. This plan of cutting is illustrated in Figure 5. In this particular arrangement the operator cuts the potato by pulling it toward him. Some prefer to push the potato against the blade of the knife. It seems easier and more logical to pull toward rather than to push away from oneself. With a good cutting box and substitute knives an active person may cut as much as 40 or more bushels per day, as against possibly 25 or 30 bushels when the knife is held in the hand.

CARE OF FRESHLY CUT SEED

It is possible to cut seed potatoes some time in advance of planting if proper conditions are provided to facilitate the suberization or corking over of the cut surface. It has been found that at a temperature of from 60° to 70° F. with an 85 per cent atmospheric humidity the formation of cork cells or periderm tissue seems to progress most rapidly. Exposure for 10 days to such temperature seems to be sufficient to insure good suberization, after which the cut seed may be held for several weeks at a temperature of 36° to 40° if desired.

If the seed is to be planted immediately after cutting, its handling in the planter will be facilitated if it is dusted with some absorbent such as land plaster, sulphur, slaked lime, or cement.

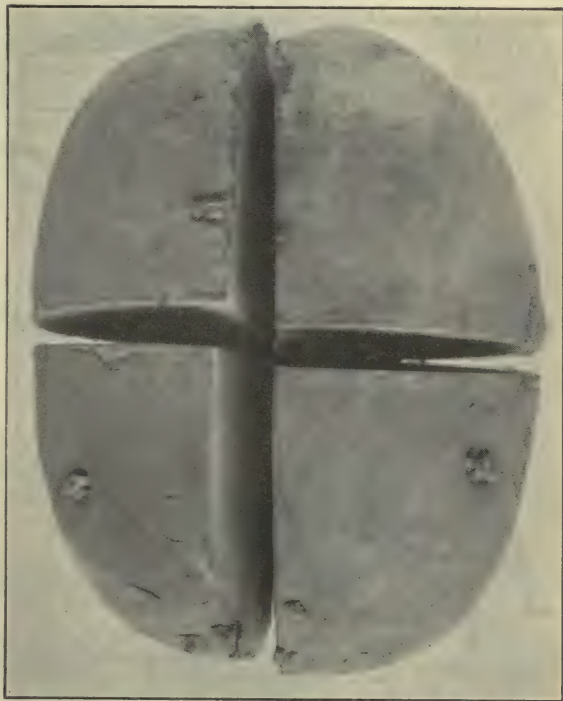


FIGURE 4.—Large blocky seed pieces insure good stands and large yields

PLANTING

The sets (seed pieces) should be planted from 3 to 4 or more inches deep, according to the type of soil and whether they are to be grown

as an early or a late crop. Shallower planting is practiced more often in the case of the early than of the late crop. Deeper planting is more necessary under dry-land farming than under irrigation.

Every effort should be made to secure as nearly a 100 per cent planting as possible. The 2-man type of planter will more nearly approximate this degree of perfection than will the picker type, although the latter will do excellent work if the seed is cut into uniform-sized, blocky sets.

SPACING

In determining the proper distance between rows and spacing of the sets in the row, it is necessary to consider the character of the soil and the available soil moisture. For example, in dry-land potato



FIGURE 5.—A potato seed-cutting box which makes it possible to cut a much larger quantity in a day and with less expenditure of energy than by using a knife in the hand

production a much wider row spacing is necessary than under irrigation. Under dry-land conditions the interrow spacing usually varies from 40 to 48 inches and the sets in the row from 18 to 30 inches. Where the normal rainfall is usually large enough to produce a good crop, as, for example, in the western portions of Washington and Oregon, the spacings may be approximately the same as on irrigated land.

Under irrigated conditions the spacing must be sufficient to permit running the irrigation water between the rows. Gen-

erally the distance between rows ranges from 36 to 42 inches, and the sets may be spaced from 9 to 12 inches apart in the rows, depending on the variety and the fertility of the soil.

IRRIGATION

The successful production of potatoes under irrigation is largely dependent upon the intelligent application and use of water. There are many practices and theories concerning the time frequency and the quantity of water to apply at each operation. There are growers who firmly believe that water should not be applied to the crop until the plants give visible evidence of low soil moisture by the dark color of the foliage and an apparent cessation of active growth. Such growers claim that it is not desirable to apply water until tuber

development has begun. Growers are also divided in their opinions as to the frequency and rate of application after this date, some preferring infrequent heavy irrigations and others the reverse. As a result of 14 years of study of early and late, frequent and infrequent, light and heavy irrigations at Greeley, Colo., it has been found almost universally that when the proper soil moisture was retained throughout the growing season, or rather up to the time the tubers had reached full size, heavier yields were rather consistently obtained. It has also been found that frequent light or medium-light irrigations were preferable to infrequent heavy ones.

TILLAGE

The practice of using a harrow or a weeder on the potato field before the plants emerge from the soil is on the increase. Many of the best growers now recognize the value of such tillage in subduing weeds and preventing the formation of a soil crust with its consequent increased water evaporation. Two such tillage operations may serve to discourage weed growth throughout the growing season.

The subsequent cultivation of the crop is dependent on whether it is being grown under dry-land, humid, or irrigation conditions. Ordinarily, for the first two of these conditions two or three cultivations subsequent to the emergence of the plants are sufficient. Later tillage might be necessary under irrigation, in order to aerate the soil and maintain deep furrows for the flow of the water.

SPRAYING AND DUSTING

In many of the Western States spraying or dusting for protection against insect pests is an effective measure of insuring good crop production, other things being equal. This is particularly true with respect to areas infested with the Colorado potato beetle and the flea beetles.

The remedy for chewing insects, such as the potato beetle and the blister beetles, is some form of arsenical poison, such as calcium arsenate, lead arsenate, zinc arsenite, or Paris green.

In the case of the flea beetles, which in their adult stage injure the potato foliage and in their immature stage attack the tuber, a combination of Bordeaux mixture and calcium arsenate or other arsenical poison appears most effective in their control. Direct control with insecticides, however, is extremely difficult.

It is seldom that the early or late blight fungous diseases are sufficiently prevalent to justify spraying with both mixtures.

HARVESTING AND MARKETING

In the early-producing sections the crop is usually harvested when it is more or less immature, depending upon market price and demand. High prices and an active demand usually mean the harvesting of decidedly immature stock.

Practically every commercial potato grower now uses an elevator type of digger to harvest his crop, whereas in 1910 all the potatoes grown on the peat lands in the Stockton, Calif., district were dug

by hand. The more common practice is to use an elevator digger drawn by either four or six horses. (Fig. 6.) Some of the larger operators are now using tractors instead of horses and are not content to dig a single row but dig two or three rows in one operation. Figure 7 shows the operation of the three-row tractor-hauled battery of diggers and the elevating and depositing of the tubers with accompanying debris into a tractor-hauled truck accompanying the digger. Figure 8 shows the process of washing the potatoes prior to sacking and marketing them.

The early-potato crop is usually marketed as it is harvested. The potatoes are picked up in wire or splint baskets and are dumped on hand or power graders and sacked, usually within less than an hour after they are removed from the ground. Throughout the West both early and late crop potatoes are invariably marketed in burlap

sacks. Most growers have come to realize that a new attractive package materially aids in marketing the crop advantageously.

STORAGE

The best types of storage houses are found in the Mountain States. Usually they are constructed so as to permit driving into them through at least one end, and in many cases of driving clear through. For further details on storage the reader is referred to Farmers'



FIGURE 6.—Operating an elevator type of digger with four horses. Note the cloddy compact soil. (Near Greeley, Colo.)

Bulletin 847, Potato Storage and Storage Houses. The bulk of the late crop of necessity must be stored for later marketing.

When the crop is to be stored, the common practice is to dump two or three half-bushel baskets into a sack, which is left untied; the sacks are then hauled to the storage house.

In Washington, Oregon, and California less attention has been given to storage houses, the bulk of the late crop being stored in pits in the open field. In the Stockton district of California the potatoes are either piled on the ranch levees and covered with tule leaves and stems or are stored in sacks in more or less open sheds.

CULTURAL PRACTICES AND PRODUCTION CENTERS BY STATES

To aid the reader in acquiring information relative to the potato industry of a given State it seems desirable to present briefly the salient facts with respect to cultural practices and production centers in each State. More specific information may be obtained from

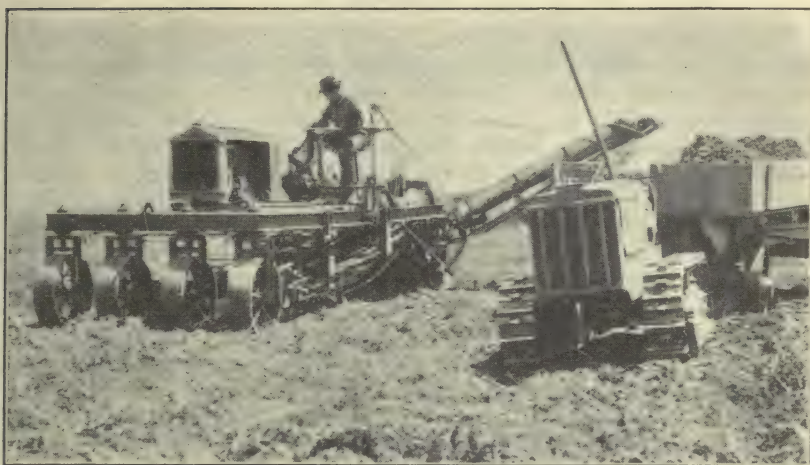


FIGURE 7.—A 3-row potato digger in operation near Stockton, Calif. This digger elevates the potatoes and transfers them to the truck. The soil and vine debris deposited with the potatoes is removed by dumping the load into a large water tank supplied with flowing water, which floats off the plant debris. The potatoes are elevated from the tank by a conveyor, which deposits them in the washer



FIGURE 8.—Washing potatoes on the wholesale plan. The tubers come out of this washer well cleaned. They drop from the conveyor belt into burlap sacks, thus avoiding hand labor

publications of the State agricultural experiment stations and from consultation with extension specialists.

ARIZONA

The potato crop of Arizona is of relatively little commercial importance. Only a small proportion of the potatoes consumed are produced in the State. The chief reason for this is that the potato can be successfully produced in only a few especially favored localities in the mountains where irrigation water is available. In such sections, as, for example, in the vicinity of Flagstaff, in Coconino County, a small Triumph seed-potato industry has been developed.

In the southern part of the State in the hot valleys potatoes do fairly well when planted at the proper time and given good cultural care. Planting in February is recommended in preference to December or January planting in southern Arizona for the early spring crop, because the plants are less liable to serious frost injury.

Planting must be done as early as possible for the potatoes to reach maturity before high temperatures injure the crop. The spring crop is usually harvested in June. A fall crop may be produced from the spring crop by planting during August or early September; the plants are usually killed by frost about the first of December. The tubers then are generally immature.

CALIFORNIA

The principal potato-producing districts in California are the delta lands of San Joaquin and Contra Costa Counties, sometimes referred to as the Stockton district; the Salinas Valley in Monterey County; the Napa and Sonoma Valleys in their respective counties—Napa and Sonoma—and the districts comprising parts of Santa Barbara, Los Angeles, and Riverside Counties.

San Joaquin County is credited by the Bureau of the Census with the production of over one-half of the total potato crop of the State in 1924 and with nearly seven times as much as that of Contra Costa County, which is the second heaviest producing county in the State. The two counties together, representing the delta lands, produced over 70 per cent of the total California potato crop, or over 72 per cent if based on the report of the Bureau of Agricultural Economics, United States Department of Agriculture. These data serve to emphasize the great importance of the delta lands of San Joaquin and Contra Costa Counties, particularly the former, in the potato industry of the State.

Owing to the large area of the State, extending as it does from about 32.5° to 42° north latitude and from about 114.5° to 124.5° west longitude, there is a wide variation in climatic conditions. As a result of this the planting and harvesting seasons extend over a considerable period. For example, in southern California the early crop may be planted from December to February or March, and the late crop in August and September or even later.

In the Stockton district, plantings may extend from the latter part of February to June 15. The bulk of the early-crop planting is made in March or April, while that for the late crop is done in May and the early part of June.

As a considerable portion of California's acreage is grown under irrigation, and as the total acreage in the Stockton district is an irrigation enterprise, the cultural practices of this district may be of interest.

The soil consists very largely of *Juncus* (tule) or other marsh plants in various stages of decomposition, varying from partially decomposed plant remains to fully developed peat and muck formation.

Only two varieties as a rule are grown in this district—the Burbank and Wisconsin Pride or American Giant. Seed of the Wisconsin Pride is mostly obtained from Minnesota or Wisconsin. Home-grown seed from this stock is used the following year. The Burbank seed is obtained from Washington or Oregon and grown similarly to the Wisconsin Pride for local seed purposes.

Fall plowing to a depth of from 10 to 12 inches is recommended, with thorough preparation of the soil in the spring prior to planting. The usual practice is to plant from 18 to 20 bushels of seed per acre, but where large acre yields are desired this quantity is practically doubled.

Deep planting, 4 to 7 inches, has been found desirable on this type of soil with the system of irrigation practiced. Close spacing of rows, also plants in the row, is general. Usually the rows are spaced from 26 to 30 inches apart and the sets (seed pieces) 8 to 10 or more inches apart in the row.

Level culture is practiced, thereby allowing the harrowing of the field before the plants appear. Irrigation is accomplished by cutting narrow ditches, spaced from 50 to 75 feet apart. These are filled with water from the main or lateral irrigation ditches, which in turn derive their water supply through siphoning it over the levees. The irrigation ditches are kept full until the water seeps through the intervening spaces. In other words, subirrigation rather than the ordinary type of irrigation is used.

The peat or muck soils permit a rapid diffusion of moisture, which is also facilitated by cutting the ditches to a depth of 20 to 30 inches. With a little wider spacing between the rows in which the narrow ditch is cut there is little loss of land or of crop due to the ditches. The deeper planting permits maintaining a dry surface soil mulch and still insuring an abundance of moisture for the plants. As soon as the soil has absorbed sufficient moisture the water is drained out of the irrigation ditches, thus permitting the land to remain sweet and well aerated. The water is usually lowered in the main irrigation supply ditches or canals by means of electrically operated pumps that discharge the water back over the levee banks into the river whence it was originally drawn. The application of water is repeated as often as may be necessary for the development of the crop.

COLORADO

Colorado has the distinction of being the second largest producer of potatoes of the western group of States, being exceeded by Idaho; and it grows the largest acreage of irrigated potatoes in the 11 States.

The leading potato-production centers in Colorado are the Greeley district in the northeastern part of the State; the San Luis Valley in the south-central part; the Grand, Gunnison, and Uncompahgre

Valleys in the west-central portion; and the Carbondale and Eagle River districts, also of the west slope.

Until 1909 the Greeley district enjoyed the distinction of being much the largest production center in the State. In that year and for several years thereafter an unusually severe and widespread attack of soil-borne diseases, such as those caused by *Fusarium* and *Rhizoctonia*, nearly ruined the potato industry. During this period the San Luis Valley section became the leading center. With the subsidence of the disease outbreak the Greeley growers have increased their acreage but have not yet returned to normal. Although the major portion of the acreage is under irrigation, many dry-land potatoes are produced in the Greeley district, a considerable portion of which is used for seed purposes.

The leading variety grown in the San Luis Valley is the Prolific (syn. Bresee's Prolific, Brown Beauty). This variety is known to the trade as Brown Beauty. Other varieties grown are the Charles Downing, Russet Burbank, Adirondack (syn. Perfect Peachblow, Red McClure), and a few Peerless and Irish Cobbler. As in the Greeley district, the bulk of the crop is grown under irrigation. In the higher valleys or plateaus—too high for the application of water—some excellent dry-land seed is produced. In the western slope valleys included in the two general production districts previously listed, the Russet Burbank and Adirondack are the leading late varieties and the Irish Cobbler, People's, and Charles Downing are the leading early and medium-maturing varieties.

The San Luis Valley potato growers have a 600-bushel-per-acre club which was organized in 1927 with 15 applications for membership. Eleven of this number succeeded in producing 600 bushels or more per acre and automatically became bona fide members. In 1928 a grower (L. G. Schutte) near Monte Vista produced 1,047.4 bushels on an officially measured acre. This yield was obtained on alfalfa sod land to which no commercial fertilizer had been applied. In 1929 he produced on the same land an estimated yield of 1,145.17 bushels on an acre.

IDAHO

Potato production in Idaho is greater and has shown a more rapid increase than in any of the other States included in the group.

Idaho has several well-recognized production centers, such as Idaho Falls, Boise, Burley, Blackfoot, and the Twin Falls irrigation project.

The soil of the Idaho Falls district is a warm sandy loam which is easily handled. Irrigation water comes from the Snake River. The Russet Burbank is the most extensively grown variety in this section; the Charles Downing is also grown. Rural New Yorker No. 2 is of some importance as a late crop.

On the Boise irrigation project Caldwell is probably the heaviest shipping point. The crop in this district consists almost wholly of the Charles Downing, which is grown largely for early marketing, being shipped as a rule during the latter part of July and throughout August. Early ripening of the plants is artificially induced by the withholding of water. In seasons when high soil and air temperatures prevail during this artificial ripening period scalding of the tubers is almost certain to induce a considerable loss from decay.

The Burley district is next in extent to that of Idaho Falls, while the Blackfoot and Twin Falls sections are of much less importance.

Seed-potato production in Idaho is becoming more and more restricted to dry-land areas, particularly in the northern part of the State. The reason is the fact that the growers in the irrigated portions of the State are recognizing that it is more advantageous to buy northern-grown seed and sell their own potatoes for table purposes instead of attempting to produce seed themselves.

MONTANA

Potato production in Montana has shown a moderate decline in recent years. The Kalispell or Flathead Lake district is the largest commercial production center. The Russet Burbank is the most important variety there. A considerable commercial potato area has been developed in the vicinity of Helena, where it is claimed that the Russet Burbank reaches a high state of perfection. A sizable Triumph seed-potato industry has been developed in the northern part of the State along the Great Northern Railway.

Montana, like most other States, can easily double or treble her present production whenever there is a profitable market outlet for the crop, but there is no prospect of such a development in the near future.

NEVADA

A situation somewhat similar to that in Montana with respect to decreased acreage and production exists in Nevada. The chief potato producing districts are the Truckee Valley, the Newlands reclamation project, and the Carson and Mason Valleys. Large areas of the Newlands reclamation project and of Mason Valley are said to be very well adapted to potato culture.

The crop is normally planted from May 15 to June 1. The Russet Burbank has become the leading variety.

NEW MEXICO

The potato crop of New Mexico is of comparatively little commercial importance. Climatic and soil conditions seem to be the limiting factors, as it is practically impossible to grow potatoes successfully in most of the valleys. High temperatures and heavy infections of the soil with *Fusarium* and *Rhizoctonia* diseases are probably largely responsible for crop failures. In some sections lack of moisture is the limiting factor.

In comparative studies of the varietal behavior of 10 lots of potatoes on the Bluewater project in Valencia County by the New Mexico Agricultural Experiment Station in 1927, the Green Mountain and Russet Burbank varieties made the largest yield, being at the rate of 157 and 115 bushels, respectively, of No. 1 tubers per acre, with a total yield of approximately 190 and 150 bushels per acre. The crop was planted on dry soil on May 7 and was irrigated on May 14, June 28, and July 11.

It is apparent from these data that there are localities within the State that are sufficiently well adapted to the potato crop to permit growing enough at least to meet the local requirements.

OREGON

Two very distinctive types of climatic conditions are encountered in Oregon, the eastern half of the State having a more or less semi-arid climate while the western portion is distinctly humid. The potato industry has shown a considerable decline in recent years.

The largest production centers are in Clackamas, Malheur, Multnomah, Marion, and Lane Counties. Potato production in Clackamas County is of interest because a considerable portion of the crop is grown on peat soil, reclaimed and irrigated in a manner similar to that of the Stockton district in California. Four of the five leading counties in potato production are in the western or humid portion of the State, while the other county—Malheur—constitutes the southeastern corner of the State.

The Blue Mountain region in the northeastern portion of the State is claimed to be the most favorable certified seed-producing area, on account of having a sufficient rainfall to produce a paying crop when good dry-farming practices are employed.

Throughout Oregon early planting seems to give best results. In western Oregon the most successful planting dates are April 1 to 15; in the Columbia Basin about April 1, and at the higher elevations from April 15 to 20.

UTAH

In point of potato production Utah occupies seventh position among the 11 States. Production has decreased somewhat, partly as a result of a partial failure of the crop in certain districts in 1927 and 1928 because of severe injury to the plants by psyllids. The following counties in the order named are the heaviest producers of potatoes: Davis, Weber, Salt Lake, Utah, and Box Elder.

WASHINGTON

The climatic conditions prevailing in Washington are very similar to those mentioned for Oregon, in that the western portion is humid and the eastern part semiarid. In point of production the State occupies third position, being exceeded by Idaho and Colorado.

Washington has two rather well-recognized irrigated sections, the Yakima and the Wenatchee Valleys, which produce considerable quantities of potatoes. The largest producing counties are Yakima, Spokane, Benton, Skagit, and King. The Yakima Valley district is noted for its production of high-class Russet Burbank potatoes.

WYOMING

In potato production Wyoming occupies eighth position in the group of States under consideration, and like some of the others, it has experienced a decline in this industry.

The principal potato-producing counties in Wyoming are Goshen, Park, Sheridan, Niobrara, and Laramie. In the Torrington district in Goshen County potato production is of comparatively recent development. The soil seems to be especially suited to the potato. Powell is in the center of the potato-producing area of Park County.

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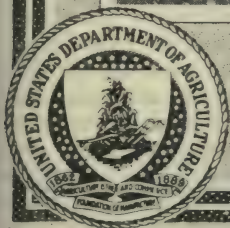


Feed

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1640

FALL-SOWN OAT PRODUCTION



FALL-SOWN OATS succeed better than spring-sown oats in most sections of the South. From 2,500,000 to 3,000,000 acres are grown annually from fall seeding. Fall-sown oats provide a winter cover for the land, thus preventing erosion. They also furnish winter pasturage and grain and forage for farm animals. The crop may be grown advantageously in rotation with corn and cotton.

The requirements for success with the crop are as follows:

A well-prepared seed bed that is firm beneath with 2 to 3 inches of mellow surface soil. Such a seed bed promotes fall growth and reduces winterkilling to a minimum.

Proper fertilization and rotation with liberal use of legumes and row crops.

Clean seed of adapted varieties treated for smut.

Early seeding with grain drill at rates of 2 to 3 bushels to the acre, assuring sufficient plant and root growth before the advent of severe winter weather.

Harvesting at the proper time to insure maximum yield and quality.

Proper protection of the grain from weather by careful shocking and stacking.

Careful storage of bundled oats as well as of the threshed grain.

The less hardy but well-adapted red-oat varieties, Red Rustproof and Fulghum, and their variously named strains, are recommended for growing in the Gulf States, Georgia, South Carolina, and the eastern portion of North Carolina. The common hardy varieties, such as Winter Turf, Culberson, Tech, and Lee, are recommended for culture in southern Maryland, Virginia, western North Carolina, Kentucky, Tennessee, and Arkansas.

This bulletin supersedes Farmers' Bulletin 1119, Fall-Sown Oats.

FALL-SOWN OAT PRODUCTION

By T. R. STANTON, *Senior Agronomist*, and F. A. COFFMAN, *Associate Agronomist*, Office of Cereal Crops and Diseases, Bureau of Plant Industry

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IMPORTANCE OF FALL-SOWN OATS

FALL-SOWN OATS succeed better than spring-sown oats in many sections of the South. Except in some of the interior valleys and coastal districts of the Pacific States, oats are grown from fall seeding only in the Southern States.

According to census figures and the annual crop estimates of the Bureau of Agricultural Economics, United States Department of Agriculture, the 16 Southern States, including Delaware, Maryland, West Virginia, Kentucky, Arkansas, Oklahoma, and those southward, grow more than 5,000,000 acres of oats annually, or from 12 to 15 per cent of the total oat acreage of the United States. Of this acreage from 2,500,000 to 3,000,000 acres are grown from fall seeding.

Fluctuations occur annually in the ratio between the harvested fall-sown and spring-sown acreages owing to winterkilling. Fall-sown oats occasionally are injured severely by winterkilling, which in the northern part of the fall-sown area usually results in a temporary decrease in the fall-sown acreage and an immediate increase in the spring-sown acreage. However, with a few favorable years for fall-sown oats the acreage increases rapidly until it is again retarded by abnormally low temperatures.

In many sections of the South oats are exceeded in importance only by cotton and corn. As the development of power farming in the Southern States as yet is not extensive, oats still are in demand as a grain feed for work animals. Oats have a relatively higher cash value per acre in the Southern States than in any other portion of the United States. This results primarily from the greater expense entailed in shipping oats from the main centers of production, owing to the longer haul and greater freight charges.

THE SOUTHERN FALL-SOWN AREA

Fall-sown oats are not so hardy as winter wheat and rye. They can be grown successfully only when and where the winters are comparatively mild. Consequently, the fall-sown oat area of the South is limited to parts of Delaware, Maryland, Virginia, West Virginia, Kentucky, Tennessee, Arkansas, Oklahoma, and Texas and to the Carolinas, Georgia, Florida, Alabama, Mississippi, and Louisiana. In the latter group of States fully 60 per cent or more of the oats usually grown are from fall seeding. The development of hardier, more disease-resistant, and more productive varieties should permit further extension of fall-sown oats in these States, as well as in those farther north.

The northern limit of the fall-sown oat area can not be definitely placed, but it is indicated approximately in Figure 1, which shows in a

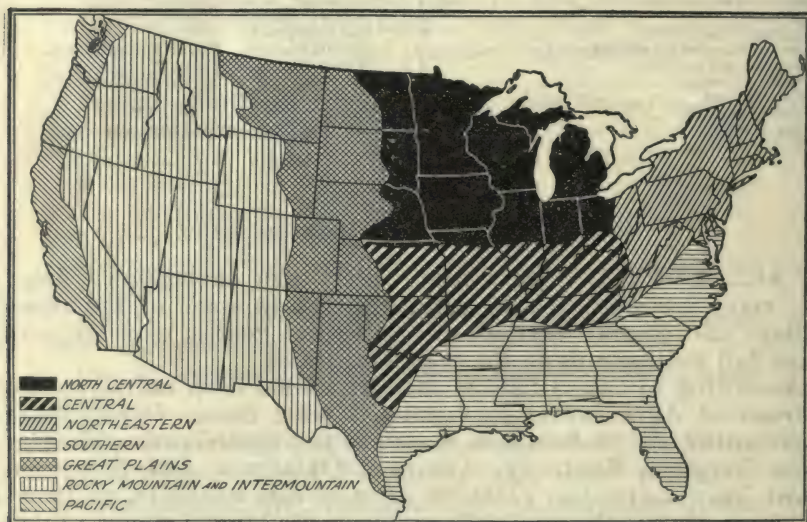


FIGURE 1.—Outline map of the United States, showing the general oat areas. In the southern and Pacific areas the crop is grown from both fall and spring seeding. In all other areas the crop is grown from spring seeding. The central area is often designated as the spring-sown red-oat area. Likewise the southern area is known also as the winter or fall-sown area. (This map is only relative and, therefore, considerable overlapping of areas exists. This is especially true along the boundary between the central and southern areas, owing to the fact that both spring-sown and fall-sown oats may be grown)

general way the oat areas of the United States. Along the northern border of the southern area there are transitional zones in which oats are grown from both fall and spring sowing with about equally good results.

ADVANTAGES OF FALL SEEDING

A satisfactory crop rotation in the southern United States should occupy the land most of the year. Soil erosion (washing) is a serious problem especially during the winter and early spring in most sections. This is reduced to a considerable extent when the soil is occupied by growing crops. Fall-sown grains have the three-

fold advantage of providing a winter soil covering, a grain crop, and some winter pasturage.

The advantages of fall seeding over spring seeding when fall-sown oats can be grown are many. Usually fall-sown oats produce larger yields and grain of better quality. Also they usually surpass spring-sown oats in yield of forage, a point worthy of consideration in the South, where much of the oat crop is not threshed but is fed in the bundle. Fall-sown oats mature earlier, and the land can be prepared for a succeeding crop to better advantage. Poorer land and less fertilizer also can be used for the fall-sown than for the spring-sown crop.

When fall-sown oats are injured severely by winterkilling the remaining plants stool vigorously. When necessary it is possible to reseed to spring oats without loss of a crop and at a minimum expense for preparing the land.

Fall-sown oats usually grow more vigorously and mature from 10 days to 2 weeks earlier than spring-sown oats. This earlier maturity allows escape from injury by heat, drought, and storms, as well as from rust and other plant diseases, and frequently marks the difference between success or failure.

The oat plant requires comparatively cool temperatures for its best development. Consequently, fall-sown oats, which mature earlier than spring-sown oats, usually are more productive and of better quality because conditions are more favorable for grain development early in the season.

SOILS

The area in which oats are fall sown is so large and contains so many widely different soil types that only the most general statements can be made. In most of the coastal plain country the land is rather level and the soil is very sandy. The topography of the Piedmont section varies from slightly rolling to almost mountainous. Heavy clay soils predominate. In the northern part of the fall-sown oat area oats are grown very largely in the mountain valleys. In these areas the soils vary from sandy loams to stiff clays.

Oats are not especially selective as to the soils upon which they may be grown with success. Almost any reasonably fertile soil in the winter-oat belt which retains moisture fairly well is suited to growing the crop. Oats require more water than do other small grains to produce the same quantity of dry matter; for this reason they suffer more quickly from drought. Any soil that will grow a good crop of cotton or corn will produce oats, although the heavier loams will give the best results, provided they are well drained.

The two chief causes of winter injury to oats are heaving and consequent root exposure, and a prolonged period of low temperatures in the absence of a snow covering. Alternate freezing and thawing of the soil in late winter and early spring is especially destructive. This occurs more frequently on clay soils, particularly those containing little humus or partly decayed organic matter. Heaving occurs less on sandy loam soils than on clay soils, especially if the former contain sufficient humus to insure a high moisture-holding capacity. To prevent winterkilling a soil must be well drained. The likelihood from winterkilling is greatest on low,

poorly drained soil. Rust and other diseases also are more likely to damage the crop when it is grown on naturally low, wet soil. Owing to less productive soils, most of the oats grown in the southern part of the fall-sown oat area do not grow so tall and vigorous as those grown in the sections farther north. Hence the danger of oats lodging is not so great. In the more northern parts of the fall-sown oat area taller varieties such as Winter Turf and Culberson are grown. Here the danger from lodging is greater.

FERTILIZERS AND MANURES

The soils of the fall-sown oat area differ so widely in topography, texture, and fertility that only general statements can be made regarding the best method of maintaining fertility. Local practice, as a rule, is the best general guide. The fertility of the soil usually is improved in one of the following ways: (1) By the application of barnyard manure; (2) by growing leguminous crops and turning them under as green manure; and (3) by the application of commercial fertilizers.

Usually barnyard manure is not available in the South in sufficient quantities to be much of a factor in soil fertility, because of the small number of livestock in this region. Dependence for maintaining soil fertility must be placed on green-manure crops and commercial fertilizers. Usually it is not advisable to apply barnyard manure directly to oats except on very poor soils. Ordinarily more satisfactory results are obtained by applying it to the previous row crop in the rotation, such as cotton or corn.

The crops most commonly used for green manures in the South are the legumes, such as cowpeas, crimson clover, vetch, velvetbeans, bur clover, peanuts, Austrian winter peas, soybeans, and red clover. Cowpeas, soybeans, and velvetbeans are the most satisfactory crops immediately to precede oats. These crops may be cut for hay, turning under only the stubble and roots, or the entire crop may be used as a green manure.

Some farmers prefer to obtain a return from the crop as pasture before turning it under. This is good practice if the soil is not allowed to become packed by tramping when wet. The fertilizing effect on the following crop is about the same whether the stubble or the entire plant is turned under, but turned-under vines add considerable humus, improving the physical condition of the soil.

If the vines are turned under, the land should be plowed if possible three or four weeks before the oats are sown, as the vines should have time to become partly decayed and the ground to become somewhat settled before seeding. If the oats must be sown as soon as the land is prepared, it is better to harvest the vines and disk the land thoroughly instead of plowing it.

The soils of the fall-sown oat area often are deficient in nitrogen, phosphorus, and potash. If the soil is acid, liming is necessary. These soils also vary widely in fertility, and the costs of fertilizers are subject to market trends. For these reasons only general statements are possible regarding the kinds and quantities of commercial fertilizer to be used.

If the soil has been liberally fertilized for other crops, phosphorus and potash need not be added for oats. Usually, however, increased

yields result from light applications of superphosphate (acid phosphate) and muriate of potash at seeding time. The proper quantity of superphosphate to apply varies. Fertile clay soils do not need so much as do the poorer sandy soils. Usually on fairly fertile soils an application of 100 to 150 pounds of superphosphate per acre will give good results. On the poorer soils from 200 to 250 pounds may sometimes be applied with profit. The rate of applying muriate of potash varies from 30 to 50 pounds on the better clay soils, and from 60 to 100 pounds on poor sandy ones. The price of the fertilizer must be considered. If the price is too high, its use may not be justified by the value of the increase in the oat crop that may be expected.

Nitrogen sometimes is the limiting element in crop production in fall-sown oat areas. If nitrogen has been supplied in liberal quantities by the application of barnyard manure, or as the result of growing legumes as green manures, there should be no need to add it in commercial fertilizers. If the green-manure crop does not immediately precede the oats, or if only a light preceding crop was harvested from the soil, some readily available nitrogenous fertilizer (ammonia) should be used. On most soil types best results are obtained by applying a top dressing of nitrate of soda or ammonium sulphate in the spring at about the time active growth starts. For sandy soils, an application of about 100 to 125 pounds of nitrate of soda to the acre may be profitable. The application may be reduced on clay soils to about 75 to 100 pounds. If the oats are to be used for hay more nitrogen should be added than where a grain crop is desired. Heavy applications of nitrogen stimulate plant growth and produce a heavy yield of straw. Nitrogen also may be applied in the form of cottonseed meal or dried blood. However, for spring top-dressing, quick-acting forms are preferable.

Results of recent fertilizer experiments in the South, particularly in Georgia, favor the use of phosphorus and nitrogen rather than phosphorus alone for fall-sown oats. As a consequence, the practice of applying superphosphate at time of seeding, and nitrate of soda to the growing crop in the spring, is to be recommended.

ROTATIONS

The best place in the rotation for oats is after a row crop such as corn or cotton. Usually corn is removed from the soil earlier than cotton, and generally oats should be sown after corn. Probably as good a rotation as has been devised for that part of the fall-sown oat area in which cotton is grown is the following:

First year, cotton with crimson clover, vetch, or Austrian peas, sown as a winter-cover crop.

Second year, corn following plowing under of the winter legume. Cowpeas or soybeans may be sown in the corn at the last cultivation, the corn to be cut as fodder and the cowpeas or soybeans and corn stubble turned under in time to seed fall oats.

Third year, fall-sown oats, followed by cowpeas or soybeans sown as a hay crop, the cowpea or soybean stubble turned under and the soil sown to rye as a winter covering, which is turned under in the spring as a green manure for cotton.

This rotation in three years gives two grain crops, corn and oats; a money crop, cotton; a hay crop, cowpeas or soybeans; and three

green-manure crops, crimson clover, cowpeas or soybeans planted in the corn, and rye. If desired, rye may afford some winter and spring pasturage before it is plowed under for cotton. By growing two crops of cotton the foregoing may be modified into a 4-year rotation. One advantage of this system is that the soil is not allowed to remain over winter without covering. Because of uncertainty in results with crimson clover, vetch or Austrian peas (the latter a comparatively new and promising winter legume) are more satisfactory for winter-cover crops.

Outside the cotton-growing section of the South a satisfactory rotation, including fall-sown oats, is as follows:

First year, corn, with cowpeas or soybeans sown at the last cultivation, the cowpeas or soybeans and corn stubble plowed under in time for fall-sown oats.

Second year, fall-sown oats with clover or grass seeded in the oats.

Third year, meadow or pasture.

If wheat is to be grown in the rotation, where clover is not adapted, and where pasture or meadow is not desired, the following rotation may be used:

First year, corn, with cowpeas or soybeans sown in the corn at the last cultivation, the land plowed in the fall and sown to wheat.

Second year, wheat, followed by cowpeas or soybeans to be cut for hay and the soil plowed in the fall for oats.

Third year, fall-sown oats, followed by cowpeas, soybeans, sorghum, or some other crop suitable for forage. Rye or crimson clover may be sown as a winter covering after the forage crop is harvested, to be plowed under in the spring for corn.

In this 3-year rotation two feed grain crops, corn and oats, are produced; one cash crop, wheat; two green-manure crops, cowpeas, or soybeans in corn, and rye or crimson clover in the wheat stubble; and two forage or hay crops, cowpeas or soybeans following oats, and cowpeas, soybeans, or sorghum following wheat.

Other satisfactory rotations similar to those named may be arranged according to the crops desired. In planning a rotation for the fall-sown oat area ample provision for green-manure crops and winter protection of the soil should not be overlooked.

PREPARING THE SEED BED

The method of preparing land for oats depends on the previous crop and on the character of the soil. The success of the crop depends largely on the condition of the seed bed and on the growth of the oats in the fall. The seed bed should consist of 2 or 3 inches of loose, mellow surface soil with a firm layer beneath. Fall-sown oats must be sown on a firm seed bed to insure the maximum protection from winterkilling.

Ordinarily when oats follow corn or other cultivated row crop in the rotation, a very satisfactory seed bed can be prepared quickly and with the minimum of expense. These crops leave the soil in comparatively good condition for oats. Furthermore, as a rule, they can be removed from the ground early enough to permit reasonably early seeding of oats, which is always an important consideration.

On land well plowed for the preceding row crop disking usually is preferable to plowing for fall-sown oats, particularly if the preceding crop has been kept reasonably free from weeds. Plowing does not always insure a firm seed bed, which is so essential for

success with the crop. The cost of seed-bed preparation by disking also is less. Disks should be sharp in order to cut successfully the corn stubble and any other plant residue left on the surface. Disking once with a tandem disk, or two diskings with a single disk, lapping half, and a harrowing usually are sufficient, though on hard, dry soils more work may be necessary.

Plowing usually is inadvisable for oats from the standpoint of cost alone. If plowing is necessary the land should be plowed to a depth of 5 to 6 inches and if possible at least a month before the oats are to be sown. The plow should be followed immediately by a spike-tooth or other smoothing harrow to work down the seed bed and thus make it more retentive of moisture. Double-disking and another harrowing should settle the soil sufficiently to put it in shape



FIGURE 2.—Disking and harrowing plowed land at a single operation for fall-sown oats in the northern part of the fall-sown area

for drilling the oats. If plowing has been delayed until just before time to seed, the roller or a plank drag may be used to make a more compact seed bed. Rolling often may be done advantageously on loose, sandy land, but on the heavier loam and clay soils the roller should be followed with the spike-tooth harrow, to break the crust and check evaporation. Commercial fertilizer should be distributed when the oats are drilled. If the seed is sown broadcast the fertilizer should be applied before the last harrowing. Disking and harrowing the soil at a single operation is shown in Figure 2. Figure 3 shows land being worked with a cultipacker preparatory to fall seeding.

PREPARING THE SEED FOR SOWING

The yield and quality of fall-sown oats may be increased considerably by proper care in preparing the seed before planting. Oats used for seed often contain large quantities of foreign matter,

weed seed, etc., which should be removed. The smuts of oats also may be controlled rather easily by seed treatment. The prevalence of smut in the red-oat varieties of the South has increased markedly in recent years, and the desirability of treating fall-sown oats has become more important than formerly.

CLEANING AND GRADING

Seed oats should be thoroughly cleaned before sowing. Fanning the seed not only removes the weak, light kernels which are not likely to grow if sown, but also removes many weed seeds. The lighter kernels may be fed to livestock, only the heavier kernels being used for seed. Most weed seeds, such as cheat (chess), a serious pest in fall-sown oat fields, can be removed by thoroughly cleaning the seed.



FIGURE 3.—Land being firmed with a cultipacker in preparation for fall-sown oats

As a rule, seed oats are cleaned with the fanning mill, but when such a machine is not available and the quantity of oats to be screened is not large, fairly efficient work may be done by pouring the oats back and forth from one container to another in a brisk wind. The lighter material will be carried away by the wind. If a considerable quantity of seed is to be sown the gain by sowing clean seed will repay the expense of buying a fanning mill or other cleaning machine.

TREATING FOR SMUT¹

At present several methods of controlling the smuts (fig. 4) of oats with formaldehyde are in use. The treatment may be applied by spraying, sprinkling, or dipping the seed. In all methods 1 pint of commercial formaldehyde (formalin) is used to each 50 bushels of

¹ Prepared under the direction of V. F. Tapke, Pathologist, Office of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture.

oats. If fewer bushels of seed are to be treated a correspondingly smaller quantity of solution will be needed. The methods differ only in the quantity of water used and the manner of applying the solution. Regardless of the method used the seed should be thoroughly fanned and screened prior to treating it.



FIGURE 4.—Normal and smutted panicles of oats. Loose smut at left, covered smut at right

Directions for spray method.—Add 1 pint of formaldehyde to 1 pint of water. This is sufficient for 50 bushels. Put the quart of solution in a hand sprayer (not a sprinkling can) and spray the oats while they are being shoveled from one pile to another. Cover the treated pile with clean sacks or covers for at least five hours, or overnight. Then sow immediately or spread out to dry.

Directions for sprinkle method.—Add 1 pint of formaldehyde to 40 gallons of water. This is sufficient to treat 50 bushels. Spread the grain to be treated

in a layer on a clean floor or canvas. Apply the formaldehyde solution from a sprinkling can while the seed is being shoveled from one pile to another. After treatment shovel the grain into a pile and cover with clean sacks or canvas for at least five hours, or overnight. Then sow immediately or spread out to dry.

Directions for dip method.—Add 1 pint of formaldehyde to 40 gallons of water. This is sufficient to treat 50 bushels. Put the seed in loosely woven burlap or gunny sacks. These should be only half filled and tied at the top. Successively dip the grain in this solution and drain until the seed is thoroughly wet. Remove the sacks from the solution and let them stand at least two hours, or overnight. Then sow immediately or spread out to dry.

Care should be taken not to put the treated seed oats into untreated bins, sacks, or machinery where it is likely to come in contact with smut spores.

Surplus treated grain may be fed to farm stock without injury, provided it is thoroughly dry and has been exposed to the air for a few days.

For more detailed directions for treating oat seed for smut the reader is referred to Miscellaneous Publication 21, Formaldehyde Seed Treatment for Oat Smuts, of the United States Department of Agriculture.

In the last few years a number of chemical dusts for the control of oat smuts have come into use and have shown promising results. It is possible that the advent of these new dusts may lead to a more widespread treatment of seed oats for smut control.

SOWING THE SEED

Oats are sown in the fall-sown oat area by one of three methods: (1) Broadcast seeding; (2) drilling with the ordinary grain drill; and (3) drilling with a specially devised drill known as the open-furrow drill.

Oats often are sown broadcast, but this method is not generally recommended. When sown broadcast and harrowed in, much of the seed is left near or on the surface, no matter how well prepared the ground may be. As a result too many plants are poorly rooted and are killed by heaving or by cold winter temperatures.

If the seed must of necessity be broadcast, a better method is to sow the seed on clean ground that has been disked, covering it about 3 inches deep with the turn plow. This should leave the surface of the soil rather rough, which will afford some winter protection for the plants. More seed should be used in broadcasting than when the oats are drilled.

The use of the grain drill in seeding oats is strongly recommended for the fall-sown oat area. Drilling produces a more uniform stand and more even germination and growth than broadcast seeding. Drilling requires less seed, and as the seed is uniformly placed in the soil at a favorable depth, the plants are less subject to winter-killing than when the seed is broadcast. Drilling at least 3 inches deep on well-prepared land, leaving the drill furrows as open as possible, is advised.

Drag chains should not be used on the drill, nor should the land be harrowed after drilling. The young plants growing in the bottoms of the rather shallow furrows made by the drill are afforded some protection from winterkilling. Figure 5 shows a disk drill in operation sowing winter oats.

Some years ago an open-furrow drill was devised by the Georgia Agricultural Experiment Station especially for use in seeding fall oats. In recent years this type of drill has been materially improved by farm-implement manufacturers, and it now is available on the market at a nominal cost. This drill sows the seed in rows from 16 to 24 inches apart. An ordinary single-row planter also may be used for the purpose. Furrow drills may be obtained with a fertilizer attachment, which distributes the fertilizer in the furrows with the seed. An open-furrow drill is shown in Figure 6.

Although the open-furrow method of sowing winter oats affords considerable protection against injury from winterkilling, it does not give perfect protection in very cold seasons. The seed is sown in drills or furrows several inches deep, so that the roots and crowns of the plants are 2 to 3 inches below the surface. These furrows



FIGURE 5.—Disk drill in operation in the northern part of the fall-sown oat area

are partly filled during the winter by the washing of the soil and alternate freezing and thawing, but the crowns of the plants still remain below the surface and are protected to some extent from cold.

TIME OF SEEDING

Fall-sown oats may be sown in many districts of the South at any time from October 1 until late December. Definite information on the best seeding date therefore is of considerable importance.

Fall-sown oats are less hardy than wheat or rye and should be sown earlier to permit them to become well rooted and make considerable growth before cold weather. Oats are seldom attacked by insects in the fall, therefore it is not necessary to delay seeding because of such pests.

In the extreme southern part of the fall-sown area along the Gulf coast seeding may be delayed until late in October or early in November. Just to the north of the Gulf coast region, in northern Louisiana, central Texas, Mississippi, Alabama, and Georgia, and

in the southeastern part of South Carolina, seeding may be done almost any time in October. In the coastal plain sections of the Carolinas and in northern Georgia, Alabama, and Mississippi, southern Arkansas, and north-central Texas the seed should be sown usually between September 25 and October 15. In the coastal plain sections of Virginia, Maryland, and Delaware, in the Piedmont and mountain sections of Virginia and the Carolinas, in the lower altitudes of southern Tennessee, in Kentucky and northern Arkansas, and in Texas and the southeastern corner of Oklahoma, the seed should be in the ground by September 20 if possible.

Results of cooperative date-of-seeding experiments conducted at Athens in northern Georgia indicate that from October 10 to 18 is about the best time for sowing winter oats in the Piedmont section

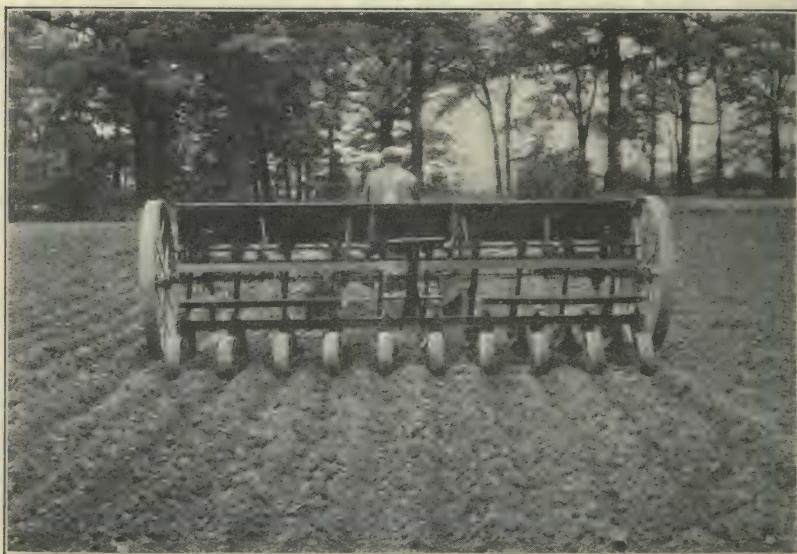


FIGURE 6.—A modern furrow drill in operation. It will be noted that the oats are sown in a distinct open furrow which affords considerable protection from severe heaving and injury by cold

of that State. At Tifton in southern Georgia results of similar experiments showed that seeding may be delayed until November 1, but as a rule a little earlier seeding is safer for the coastal plain section of Georgia. The results of these experiments on the whole show that late seeding is one of the factors most responsible for the low yield of fall-sown oats in the South. This is particularly true in the northern portion of the area.

Early seeding of fall-sown oats is very important if the crop is to give a favorable return.

RATE OF SEEDING

Results of experiments conducted at several experiment stations in the South show rather conclusively that heavy seeding rates are advisable for fall-sown oats. In Georgia it has been found that the best rate of seeding may vary with the variety sown. From $1\frac{1}{2}$ to 2

bushels per acre was found to be the best rate for Red Rustproof, and $2\frac{1}{2}$ bushels for Fulghum. In other localities the seeding rate may be different. When seeding is done with the open-furrow drill it is usually advisable to sow 2 bushels of seed to the acre, and with the ordinary drill $2\frac{1}{2}$ bushels of seed should be used. Broadcast seeding requires still more, from 3 to $3\frac{1}{3}$ bushels being necessary.

In the northern portion of the fall-oat area, where the danger from winterkilling is great, and even farther south when the crop is sown late in the fall, it is necessary to increase the rate of seeding. From $2\frac{1}{2}$ to 3 bushels per acre of Fulghum, and from 2 to $2\frac{1}{2}$ bushels of varieties like Winter Turf (Virginia Gray), Culberson, and Lee, are about the proper rates of seeding for the colder portions of the fall-oat area.

If the oats are to be used for pasture or hay, somewhat heavier seeding is advisable than when the grain crop is the chief consideration. Where oats are used as a nurse crop for clover or grass, or where grown with vetch or crimson clover, less seed is needed than when oats are grown alone.

CULTIVATION

As a rule, winter oats are given little or no cultivation after seeding. Sometimes oats are harrowed after the plants are well through the ground, to destroy weed growth. Where a large number of small weeds appear in the fall after the oats have become established, many of the weeds may be destroyed by a light harrowing before winter. To prevent the harrow from damaging the crop the teeth should be set to slant backward so as to stir a minimum amount of soil, yet destroy the maximum number of small weeds. Such practices are only partially successful and usually are impracticable.

Injury from heaving in the winter and early spring sometimes may be reduced by rolling the land as soon as possible after the heaving takes place. Clay soils, the type most likely to be subject to heaving, should not be rolled while wet.

Some farmers remove large weeds from their oat fields by pulling or digging. Some oats may be tramped down in the operation, but the grain lost probably is more than compensated for by eradicating the weeds and preventing their seeding. Sprays and other chemicals to kill weeds in oats have not proved practicable.

HARVESTING THE CROP

CUTTING

Fall-sown oats usually are cut with the grain binder (figs. 7 and 8), but when the area is too small to justify the use of this machine, the mower, or even a cradle or a scythe, may be used. The percentage of oats in the fall-sown area cut with the harvester-thresher combine is rather small as yet, although this machine apparently is gaining in favor each year.

If the oats are cut with the binder they should be allowed to stand until the upper kernels in the panicle have passed the hard-dough stage. If the oats are cut too green they are likely to mold in the shock, and if the harvest is delayed too long shattering is likely to

result. The red oats widely grown in the South may shatter somewhat if allowed to become thoroughly mature before harvest. If the oats are cut with the mower or by hand they should be cut a trifle greener than when the binder is used, in order to prevent undue shattering. Cradled oats may be allowed to cure in the swath a few days before binding.

SHOCKING

If oats are cut a trifle green in order to utilize the straw for roughage or to avoid damage from storms, they may mold if shocked at once. If allowed to dry somewhat in the windrow the likelihood of damage is considerably lessened. When oats are cut in the hard-dough stage they usually can be shocked as fast as cut, without danger.



FIGURE 7.—Harvesting fall-sown Red Rustproof (Appler) oats with binder and tractor in Georgia

In the southern part of the United States special care should be given to the shocking of oats, as injury from rains is more likely to occur there than in many other sections.

Two types of shocks are commonly used for oats, the long type and the round one. The round shock is used almost exclusively in the South. The properly capped round shock probably will resist rain better than the long shock.

Ordinarily from 10 to 12 bundles are used in setting up a round shock. (Fig. 9.) One or two extra bundles are used for capping. Smaller shocks may be built, but usually they do not stand so well and more grain is exposed to the weather. The shocks should be carefully built. Proper shocking will insure grain of higher quality under nearly all conditions.

STORING AND STACKING

In many parts of the southern oat area, oats are stored in barns in the bundle, as the greater portion of the crop is fed to work stock without threshing. All bundle oats should be thoroughly dry and well cured in the shock before storing in barns for long periods of time. Such grain should be protected as much as possible from rats and other vermin, as well as from the Angoumois grain moth. Thorough cleaning of barns or other storage space to get rid of all material favorable to the breeding of rats, moths, etc., before storing the grain is a good precaution.

If stacking is necessary it is essential to build stacks that will protect the oats. The stack should be placed in a dry location. It often is best to make a foundation by laying down fence posts or poles or other light timbers to keep the oats off the ground. The size of the foundation will vary with the size of the stack. In stacking,



FIGURE 8.—Harvesting fall-sown Nortex oats with binder in Texas

the center of the stack always should be kept well tramped, well filled, and free from holes. The outer row should not be tramped, so that when the stack settles the straw of the exposed bundles or butts will slope distinctly downward and shed water perfectly.

Properly completing and securing the top of the stack also is important. The top of the stack should taper gradually and symmetrically to a point. The few last bundles should be put on like the cap bundles of a shock. They may be held in place by driving a sharpened stake 6 to 8 feet long down into the center of the stack. Weights made of two light timbers tied together with wire or rope also may be hung over the top of the stack to keep the top bundles in place. Where stacking is necessary, attention to these and other details will insure more complete protection of the grain.

THRESHING

Oats may be threshed from the shock or from the stack. Threshing from the shock should never be attempted when the oats are

damp. Oats may be threshed either before or after sweating in the shock. When threshed before sweating the grain will go through the sweat in the bin. If oats are dry when threshed from the shock, even before going through the sweat, there is little probability that they will be bin damaged. Usually it is better to allow oats to become well cured in the shock, stack, or mow before threshing. When stacking is practiced sufficient time usually elapses to allow the oats to become thoroughly stack cured.

The essentials of good threshing are that all grain be removed from the straw, that the grain be not cut unduly by the cylinder teeth, and that the separator do a reasonably good job of cleaning. By strict attention to detail it is possible to keep oat varieties in a pure



FIGURE 9.—Shocking fall-sown Red Rustproof oats in a field in Madison County, Miss. Well-built shocks, properly capped, help to protect the grain from injury by weather

condition for a number of years, and also to prevent the spread of noxious weeds from farm to farm. Care should be taken to see that the separator is thoroughly cleaned prior to being brought to the farm, if varieties are to be kept in a reasonably pure condition.

As oat straw is widely used for roughage, care should be taken to protect it from the weather. If barn or mow space is not available for storage, the straw should be stacked. Oat straw is a valuable roughage for livestock, being superior to wheat or barley straw. The straw not needed for roughage should be used for bedding farm animals and the making of manure.

WINTER OAT VARIETIES

Varieties of two rather definite groups of oats are grown in the South from fall seeding. The first group includes the less hardy

Red Rustproof and Fulghum varieties and their variously named strains. The second group includes the hardier and more cold-resistant Winter Turf, Culberson, Tech, and Lee varieties.

The growing of the red-oat varieties from fall seeding is limited to the southern portion of the winter-oat belt (the Cotton Belt proper). The more hardy varieties, such as Winter Turf and Culberson, are grown in the northern portion of the winter-oat belt, extending from Virginia westward through Kentucky, Tennessee, and Arkansas.

RED RUSTPROOF

Red Rustproof and its strains are the most widely grown of the fall-sown oat varieties. The straw is short to midtall, straight and stiff, and of a reddish color. The panicles are rather small with ascending branches. The kernels are large, broad, and plump, and reddish brown. Both kernels of the spikelet often are awned, the awn usually being straight and weak. In most of the fall-oat area Red Rustproof ripens as a midseason variety when compared with Fulghum. Usually it is relatively free from smut, and most strains are more or less resistant to crown rust, although the name Red Rustproof is misleading as to its rust resistance.

There are several named strains of Red Rustproof. Some of the best known are Texas Red Rustproof (also called Red Texas, or Texas Red), Ferguson No. 71, Bancroft, Appler, Cook, Coker Appler, Hasting (Hundred Bushel), Ferguson No. 922, Patterson, and Nortex. All of these are similar in appearance, and nearly all were originated at one time or another as selections. Some of the best known of the older strains are Appler, Bancroft, Cook, Hasting, and Ferguson No. 71. The more recent improved strains are Nortex and Ferguson No. 922.

Nortex was originated by the Texas Agricultural Experiment Station at substation No. 6 (Denton). It is typical of the Red Rustproof variety. Its superior characters are high yield, stiff straw, and maturity from one to three days earlier than ordinary Red Rustproof. Nortex is recommended especially for fall seeding in north-central Texas. It has been registered (Reg. No. 67) by the American Society of Agronomy and the Bureau of Plant Industry as an improved variety of merit.

Ferguson No. 922 is a recent production of the Ferguson Seed Farms, Sherman, Tex. It may replace to some extent the original Ferguson No. 71, which has been a standard strain of Red Rustproof in northern Texas. Ferguson No. 922 is a fairly high-yielding strain of Red Rustproof, but it is not superior to the old No. 71 or to Nortex in uniformity and productiveness.

FULGHUM

Fulghum doubtless is the most important distinct variety of oats having its origin in the United States. It was originated a few decades ago in southeastern Georgia as a plant selection in a field of Red Rustproof oats. The initial selection was made by a man named Fulghum. Probably it resulted from a natural hybrid. It first came into prominence in that section as a fall-sown oat, and its possibilities as a spring-sown oat were discovered later. Its exten-

sion in the South as a fall-sown oat has been rapid, until in recent years it has rivaled the Red Rustproof in importance.

Fulghum differs from Red Rustproof when grown under conditions of fall sowing in that it is earlier in maturity and a little taller and has more slender kernels which are less often awned and bear fewer basal hairs. Fulghum is more susceptible to crown rust and to smut than Red Rustproof. Among the strains of Fulghum mainly used for spring seeding, but grown to some extent from fall seeding, are Kanota and Frazier.

At the Arlington Experiment Farm of the United States Department of Agriculture at Rosslyn, Va., several promising Fulghum strains have been developed that are decidedly more cold resistant than the original Fulghum. The commercial value of these is not fully determined.

WINTER TURF

The Winter Turf variety, also called Virginia Gray, Winter Grazing, Gray Winter, and several similar names, often is considered better adapted to pasture and hay than to grain production. The plants are more spreading in early growth than those of the Red Rustproof variety and are much more winter-hardy. The leaves are narrow and dark green. The straw is rather tall and slender, and the panicles are large, open, and spreading. The kernels are midsized, usually gray in color, with distinct dark-gray lines running from the kernel base to the tip. Winter Turf usually is both awned and awnless, but the awns break off readily in threshing. The variety is not resistant to rust or smut and is subject to lodging. Winter Turf is adapted to the northern portion of the fall-sown oat area. Farther south it matures too late and often is injured by hot weather and drought. It is very uniform in all plant characters and is easy to identify and maintain in pure stocks. The several names applied to it sometimes may denote distinct physiological strains, which, however, usually conform to the Winter Turf type in all observable characters.

CULBERSON

The Culberson variety resembles Winter Turf in some characters, differing mainly in having dull, white or grayish kernels which usually bear awns. It is somewhat earlier than Winter Turf but slightly less winter-hardy. Culberson is little grown at the present time. There are several strains of Culberson, the Dwarf Culberson and Hairy Culberson being best known. These are early and short-strawed selections of the original variety, the latter differing from Dwarf Culberson in that the young plant is covered with short hairs. Dwarf Culberson is grown to a slight extent in Tennessee.

TECH

Tech (also known as V. P. I. No. 1) is a selection originated by the Virginia Agricultural Experiment Station at Blacksburg. It is not easily confused with any of the other fall-sown varieties because of its black kernels. Owing to some prejudice against black color in oats, it is not likely that Tech will become of widespread commer-

cial importance. However, in Virginia it has shown considerable winter resistance and also high-yielding ability. It matures from a week to 10 days earlier than Winter Turf, which is a decided advantage under some conditions. Tech has been registered (Reg. No. 63) as an improved variety of merit by the American Society of Agronomy and by the Bureau of Plant Industry. Strains similar to Tech, known as Hatchett and Black Winter, have attained little commercial importance.

NEW VARIETIES

Several new and promising varieties of winter oats have been developed in the last few years. The merits of these have not been fully demonstrated on farms. Among these are Lee and Custis, originated by crossing Winter Turf with Aurora, an early oat lacking cold resistance, but with short, plump, thin-hulled kernels. In these two varieties the desirable characters of the parent varieties have been combined to a high degree. They are nearly as cold resistant as Winter Turf and have the excellent kernel characters of Aurora. The range of Lee and Custis apparently is limited to the northern part of the fall-sown oat area in southern Maryland, Virginia, western North Carolina, Tennessee, and Arkansas. They are not adapted to the Cotton Belt. Lee has been registered (Reg. No. 64) by the American Society of Agronomy and by the Bureau of Plant Industry as an improved variety of merit.

FALL-SOWN OATS FOR HAY AND GRAZING

Fall-sown oats make an excellent hay and winter-grazing crop for stock of all kinds. The crop may supply considerable pasturage and later may be used for hay or grain. Oat hay is easily cured and very palatable to farm animals. The yield and feeding value may be increased by growing the oats in mixtures with some winter legume, such as hairy vetch. This combination is the most popular hay mixture in much of the fall-sown oat area. The crop may be grazed during the winter and still produce valuable hay when cut in late spring or early summer. In the southern part of the fall-sown oat area, lespedeza, a spring or summer legume, may be sown in the oats without covering the seed in February, thus providing summer grazing without additional cost.

Pasturing fall-sown oats may reduce the yield of grain. However, judicious pasturing of the growing oats sometimes may be an advantage from the standpoint of grain production. When fall-sown oats are grown on fertile soils and not pastured, considerable lodging may occur with consequent loss of grain. Under these conditions pasturing is beneficial. The winter pasture supplied by fall-sown oats in some sections of the South, particularly in Texas, is an incidental crop of considerable importance. When a winter-grain crop is sown primarily for pasture it is usually better to use wheat or rye, as these crops can be pastured more closely than oats and still produce a fair crop of grain. Oats should be closely pastured only when the land is to be plowed and used for some other crop in the spring.

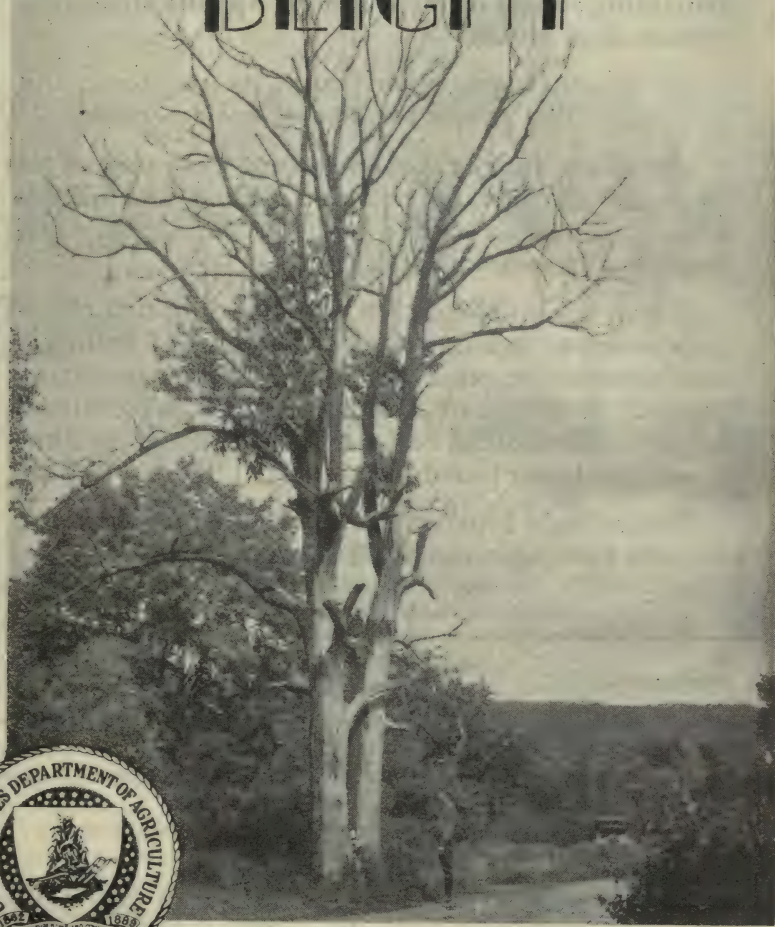
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U. S. DEPARTMENT OF
AGRICULTURE

FARMERS' BULLETIN No. 1641

CHESTNUT
BLIGHT



U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE BULLETIN NO. 144

CHESTNUT BLIGHT, caused by a fungus brought into this country from Asia before 1904, is responsible for the death of millions of acres of chestnut growth in New England and the Middle Atlantic States. The disease spread rapidly to nearly all parts of the range of the native chestnut, and the remaining stands of the southern Appalachians face certain destruction.

The present known distribution, its symptoms, and the fungus that causes the disease are described.

The blight fungus itself does not have any effect upon the strength of chestnut timber, and blight-killed trees can be utilized for poles, posts, cordwood, lumber, and extract wood.

Search is being made for native and foreign chestnuts resistant to the disease in the hope of finding a tree suitable for replacing the rapidly disappearing stands. Seedlings of Asiatic chestnuts, which have considerable natural resistance even though not immune, are being tested in the United States.

This bulletin supersedes Department Circular 370, Chestnut Blight in the Southern Appalachians.

CHESTNUT BLIGHT

By G. F. GRAVATT, Senior Pathologist, and L. S. GILL, formerly Associate Pathologist, Office of Forest Pathology, Bureau of Plant Industry

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INTRODUCTION

THE PARASITIC FUNGUS, *Endothia parasitica* (Murr.) A. and A., that causes the disease of chestnut known as the blight or bark disease, was brought into the United States from Asia before this country had enacted plant-quarantine laws. As is often the case with introduced plant and insect pests, the chestnut-blight organism proved to be more virulent in the home of its adoption than in its native habitat. Chestnut blight was first observed and recognized as a new disease in this country at New York City in 1904, though it must have been present for some time previous to that date. The millions of acres of chestnut growth north of the Potomac River and east of the Allegheny Mountains have been killed by the blight fungus, and the remaining American chestnut stands of the southern Appalachian Mountains are heavily infected and face certain destruction.

SPREAD OF THE BLIGHT

The disease spread rapidly from its original infection center at New York City and later from other centers. It soon covered New England, but it made its most rapid advance in a southwesterly direction from New York City along the eastern slopes of the Blue Ridge and Allegheny Mountains.

The blight fungus not only spreads from infected trees to healthy ones near by, but often it is carried for long distances on shipments of chestnut poles or nursery trees and by birds or wind. Under favorable conditions such distribution of the fungus may result in new centers of spread, known as spot or advance infections. The rapid progress of the blight over the chestnut area is largely due to the fact that these advance infections become established many miles ahead of the main infection area. These advance spots rapidly enlarge, run together, and form a continuous infected area. The plan of the early work in Pennsylvania and other States was to locate

and cut out these advance infections to delay the spread of the disease. The cutting-out work in Pennsylvania resulted in marked delay in the spread of the disease across that State.

The blight has now extended to nearly all parts of the range of the native chestnut. In the extreme southern and western parts of its botanical range there are probably a number of small healthy stands of chestnut, but the steady spread of the blight means that these will be infected soon. The disease reaches isolated small stands of native chestnut that are many miles from any other chestnut or chinquapin growth. As the southern chinquapins are susceptible to the blight, these bushes will serve as hosts for the disease in localities where no native chestnuts grow. The percentage of infection in the southern Appalachians can be expected to increase steadily until the stand is finally killed. Table 1, based on observations on certain areas in Maryland and Virginia, gives a fair idea of the general rate at which infection and killing can be expected to increase, after the stand reaches the stage of 1 per cent infection.

TABLE 1.—Rate of increase in chestnut-blight infection after 1 per cent infection has been reached

[Percentages based on studies made on a number of areas in Maryland and Virginia]

Period after infection reaches 1 per cent	Healthy	Infected			Period after infection reaches 1 per cent	Healthy	Infected		
		Infected but not dead	Dead	Total			Infected but not dead	Dead	Total
Years	Per cent	Per cent	Per cent	Per cent	Years	Per cent	Per cent	Per cent	Per cent
1	97	3	0	3	8	5	80	15	95
2	90	10	0	10	9	1	69	30	99
3	80	20	0	20	10	0	45	55	100
4	60	40	0	40	11	0	25	75	100
5	40	60	0	60	12	0	15	85	100
6	20	78	2	80	13	0	10	90	100
7	10	85	5	90	14	0	5	95	100

PRESENT DISTRIBUTION

The estimated distribution of the chestnut blight in the southern Appalachians in December, 1929, is shown in Figure 1, which is based primarily on reports of cooperators and supplemented by very limited survey work by members of the Office of Forestry Pathology. The degrees of infection and killing are estimated upon a county basis, though the actual infection within a county varies greatly. For example, a county having an average of 50 per cent of its trees blighted usually contains areas where the actual infection is less than 5 per cent and others where it is over 95 per cent. In using the map it must be remembered that these figures on infected and killed trees are not the result of detailed surveys of each county but are merely estimates based upon the best available information in the fall of 1929.

No detailed records are available upon the prevalence of blight in the scattered tracts of chestnut timber in those parts of the Southern States outside the Appalachian Mountains where the species is of minor importance. In a general way it is known that a major part

of this scattered growth has been killed in eastern Virginia; that a large percentage of it is infected in North Carolina, Kentucky, and Tennessee; and that a few scattered infections are present in Alabama and Georgia. Extensive inspection work would undoubtedly result in the finding of widespread infection in this scattered growth.

The blight has been reported on wild and planted chestnuts at a number of points in Indiana and Michigan. A large percentage of the chestnut growth in Ohio is infected or killed, the severity of infection being less in the southwestern than in the eastern part of the State.

Nearly all of the original chestnut trees have been killed in the Middle Atlantic and New England States. In the northern parts of New York and the New England States the blight has also killed many of the isolated trees at the extreme edge of the distribution area of the species. It has also been reported at a number of places in Ontario, Canada.

SYMPTOMS OF THE DISEASE

The symptoms of blight are so characteristic that owners of chestnut should have no difficulty in recognizing the disease. The yellow or brown leaves of a dead branch, standing out in striking contrast to the green foliage, are usually the first-noticed indications of the presence of the chestnut blight. If the branch is killed in early spring, the dead leaves are smaller than normal ones (fig. 2), while if it is killed later in the season the leaves usually attain their full size. The dead leaves and burs of killed branches, which usually remain attached during the winter, afford a means of detecting blight infections at that time of year. Dead limbs without leaves or burs often indicate the presence of the blight. Occasionally dead branches with attached leaves result from causes other than the blight, but when the blight fungus, which is described in detail on page 7, is responsible, a close examination of the stem or branch will reveal the presence of a canker located on the branch or the trunk, usually somewhat below the lowest killed leaves. The sprouts or suckers that frequently develop below cankers aid in locating them. (Fig. 3.)

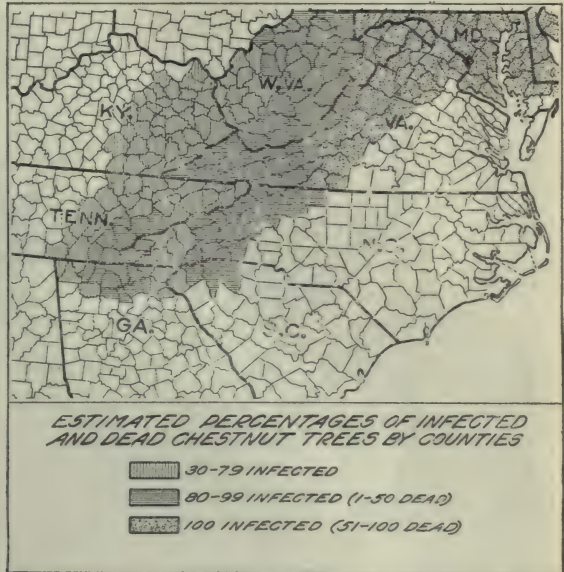


FIGURE 1.—Estimated distribution of blight in the more important chestnut counties of the southern Appalachians in December, 1929. Each year the degrees of infection and killing increase

Cankers on smooth bark are easily recognized by their yellowish brown surface color, which contrasts sharply with the grayish green color of normal bark. The margin of the canker may be slightly raised in some cases, and in others it may have a water-soaked appearance, especially on vigorously growing shoots. Usually the margin of the canker is fairly regular (fig. 4), but



FIGURE 2.—An orchard chestnut partly killed in early spring. It shows very small leaves in contrast with normal ones

sometimes it is irregular. (Fig. 5.) There is less contrast between the appearance of the canker area and its margin on slowly growing shoots or twigs.

The cankered areas may be either sunken below or raised above the surrounding healthy bark, or a single canker may have both sunken and raised parts. When the fungus promptly kills the bark all the way through to the cambium and into the wood, there results

on smooth shoots a sunken area, which usually has a smooth, uncracked surface; but when it fails to kill the cambium, new layers of bark cells are formed underneath the attacked area and an enlarged lesion results. The swollen cankers usually have a number of longitudinal fissures or splits. (Fig. 6.) Frequently cankers have a smooth sunken area of bark in the center (fig. 6) and raised margins with cracks and fissures in the swollen parts.



FIGURE 3.—A swollen blight canker with suckers developed below the infected area

On large thick-barked limbs and trunks a young blight infection causes very little change in the outward appearance of the bark. As the disease progresses abnormal splits or cracks often appear and expose some of the buff-colored infected inner bark, which is different in color from the surface bark. The presence of yellow, orange, or reddish-brown pustules about the size of a pinhead in

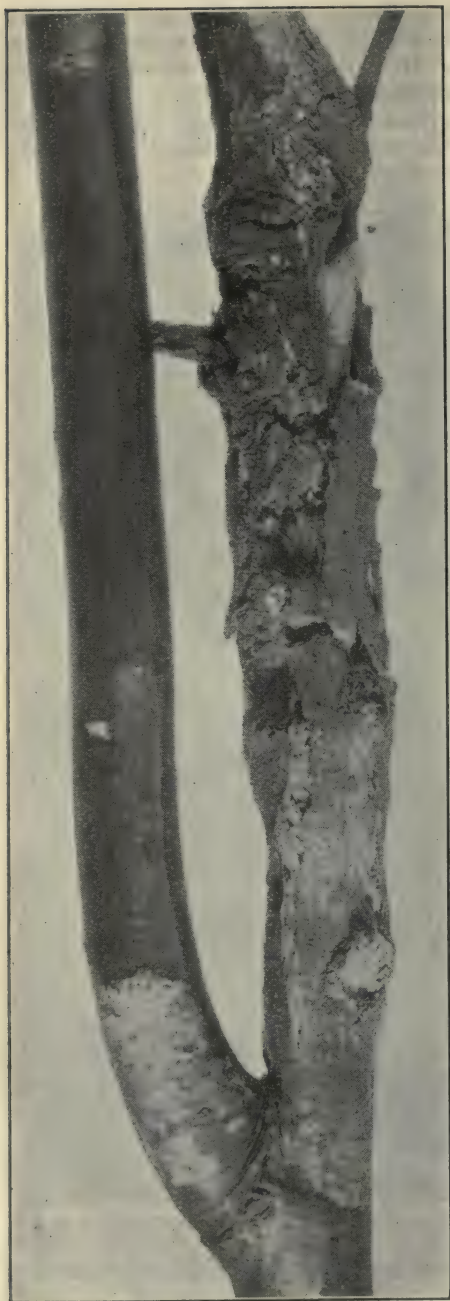


FIGURE 4.—Old blight canker spreading to a sprout. The canker developed there had a regular margin

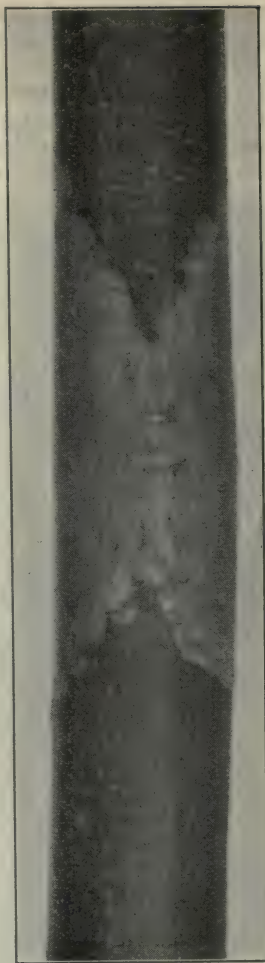


FIGURE 5.—A blight canker with an irregular margin. The fungus started on the opposite face of the limb and the two edges of the lesion have just grown together

the cracks or crevices of the thick bark is another indication of the disease. These pustules develop much more abundantly on the surface of cankers on smooth young growth than on those on thick-barked stems.

In many localities in the Southern States, especially at the lower elevations, many of the chestnut trees have died presumably from a root-rot disease that is quite distinct from the chestnut blight. Trees

affected by the blight always have cankers that show the typical fruiting bodies and cycelial fans as described on page 7. (Fig. 7.)

THE CAUSAL ORGANISM¹

The vegetative part of the blight fungus, which is made up of very numerous flattened threadlike strands, is called the mycelium.

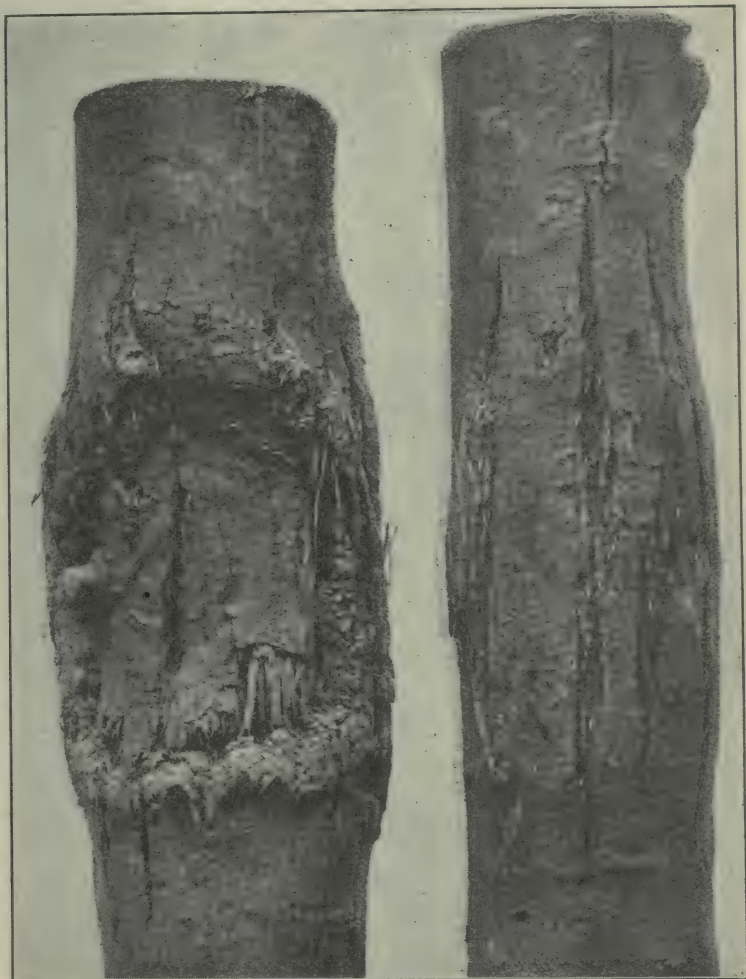


FIGURE 6.—The central part of the canker at the left is sunken where the fungus has killed the bark through to the wood. The canker at the right is slightly swollen with characteristic cracks.

It grows in the bark, extending much like the roots of plants in soil. As the fungus penetrates, it brings about the death of the invaded bark. The mycelium within this dead area is buff colored, but where it extends into the living bark at the margin of the lesion it is often

¹ SHEAR, C. L., STEVENS, NEIL E., and TILLER, RUBY J. *ENDOTHIA PARASITICA* AND RELATED SPECIES. U. S. Dept. Agr. Bul. 380, 82 p., illus. 1917.



FIGURE 7.—Mycelial fans of the chestnut-blight fungus. This is one of the most important diagnostic characters. Usually the mycelial fans are much less abundant than in this specimen

white. The term "fans" has been applied to describe these thin spreading plates of fungous growth. (Fig. 7.)

When well established the fungus fruits. The reproductive bodies formed, corresponding to the seeds of plants, are known as spores. Two types of spores are produced from pustules, which in dry weather resemble orange or red-brown pinheads dotted over the surface of the cankers. (Fig. 8.) During damp weather certain pustules produce tiny yellow, coiling, hairlike tendrils, called spore horns (fig. 9), which are composed of myriads of spores about the size of bacteria. These spores are borne within the pustule in such

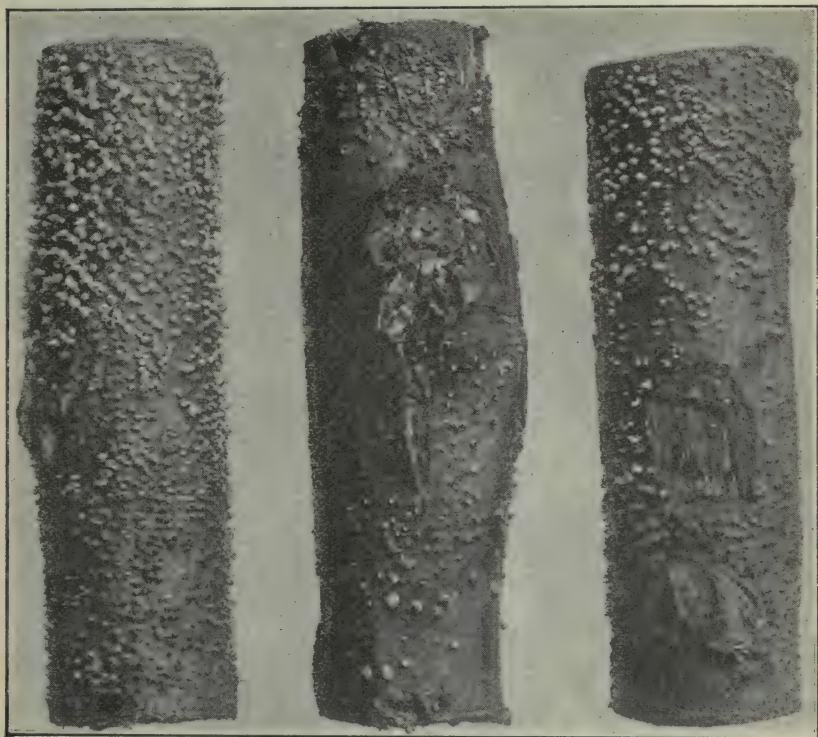


FIGURE 8.—Fruiting bodies of the chestnut-blight fungus

numbers that when moist they are forced out in a slender serpentine mass, much as paste is squeezed from a tube. Spores of this type are sticky when moist. They adhere to insects, birds, and animals coming in contact with them and thus may be carried long distances. Rain dissolves the dry spore horns and washes the spores into worm-holes and wounds to start new cankers.

Pustules producing the second type of spore differ from those producing the first in that during wet weather they are dotted with very small openings rather than surmounted by spore horns. The openings, which are often at the end of small protuberances (fig. 8), are the mouths of flask-shaped structures. Within the flasks the spores are borne, definitely arranged in groups of eight 2-celled spores. Each group is inclosed in a thin, transparent, club-shaped

sac. Under suitable conditions the sacs escape through the neck of the flask. When free the sacs burst in miniature explosions, throwing the spores into the air. Thus freed the spores are carried by air currents often to great distances.



FIGURE 9.—Spore horns of the chestnut-blight fungus. About six times natural size

The enormous numbers in which both types of blight spores are produced, together with the fact that they are adapted for different methods of dissemination, give insight into one aspect of the difficulty of halting such a foreign invader once it becomes widely established and begins its march.

DETERIORATION OF WOOD

Tests made by the United States Forest Products Laboratory² indicate that for a year, or possibly two years, wood from blight-killed chestnut is as good as that from healthy chestnut. As the blight fungus itself does not appear to have any immediate or after effects upon the mechanical strength of the timber; the utilization value of a blight-killed chestnut should be no less than that of a tree ringed with an ax at the same time and left standing. Soon after the death from either cause, the loosening of the bark, which is accompanied by decay of the sapwood, becomes apparent. Figure 10 shows the average rate at which the bark was observed to loosen and

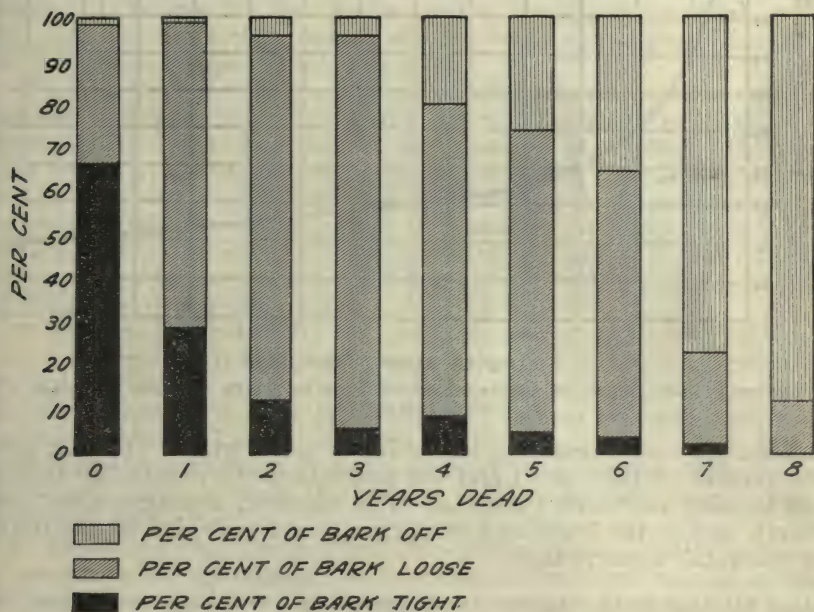


FIGURE 10.—Condition of bark on trees dead for periods of different length

fall from the first log of blight-killed trees at several localities in the southern Appalachians. The very rapid loosening during the first three years after death is brought about largely by insects and fungi, which finally cause it to slough off. Occasionally certain species of fungi also decay the heartwood to a depth of an inch or more. The amount of sound sapwood remaining on the first log during the first seven years after death is approximately the same as the amount of tight bark shown in Figure 10.

Since most of the loosened bark and decayed sapwood will be knocked off in felling operations, they can be considered almost a complete loss by the third or fourth year after death. The reduction in volume resulting from the loss of sapwood and bark on the trunks alone, where trees were cut into 5-foot sticks to a 4-inch minimum diameter for extract wood, is shown in Figure 11, which is

² A UTILIZATION GUIDE FOR BLIGHT-KILLED CHESTNUT. U. S. Dept. Agr., Forest Products Lab., Technical Note 224. [Multigraphed.]

based on 78 trees. It is evident that the loss in proportion to original volume is heaviest in trees under 8 inches in diameter. No data are available for trees above 17 inches, but allowing for a conservative increase in bark thickness with diameter, it is estimated that the loss will still closely approximate 20 per cent in the 30-inch diameter class.

The percentage of loss in limb wood will be consistently higher because of the greater proportion of small diameters. However, as the trunk volumes have been calculated to a 4-inch upper limit, the

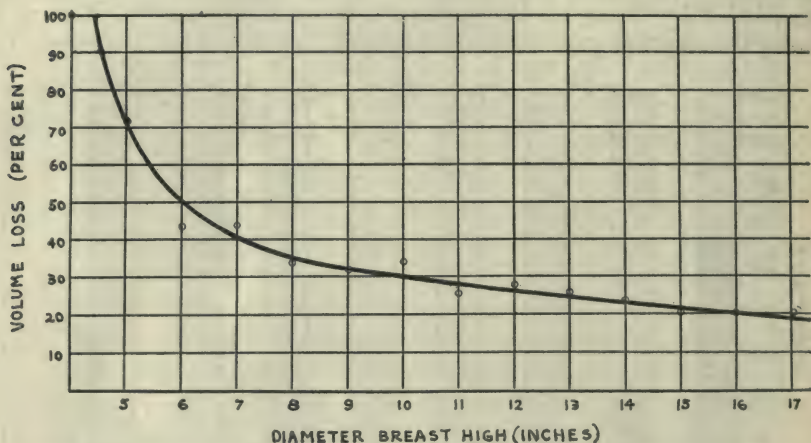


FIGURE 11.—Reduction in volume of extract wood in trunks resulting from loss of bark and sapwood

amount of wood remaining in the limbs is not great. Table 2 gives the amount of limb wood and the percentages of loss in 319 trees at one locality in North Carolina. The sapwood averages about one-fourth inch in thickness and comprises about one-third to one-fourth of the total amount lost.

TABLE 2.—Limb-wood volumes and percentages of loss through bark falling and decay of sapwood

Diameter breast high (inches)	Trees	Average volume of limb wood	Loss in bark and sapwood
	Number	Cubic feet	Per cent
15 to 19 inches.....	99	1.39	49
20 to 24.....	123	3.47	59
25 to 29.....	66	7.00	35
30 to 34.....	31	10.01	31

The heartwood of living chestnut is often attacked by certain fungi that cause it to decay. Some of these heart-rotting fungi are able to continue to decay the wood in standing dead trees, but how fast heart rot progresses in trees infected with rot before death is not known. In the case of sound trees there will probably be little danger of any material loss in volume from center rot for the first 10 years after death, and many standing trees have been found to be apparently sound 30 years after they have been killed. After 10 years, however, wind throw must be considered. Trees on the

ground usually deteriorate more rapidly than those that remain standing. Their centers are frequently destroyed within a few years by insects in combination with decay. The time required for blight-killed trees to fall is dependent upon a number of factors, among which are soil type, local weather conditions, relief, exposure, and prevalence of root decay. Observations on a number of belted or girdled areas in the southern Appalachians indicate that less than 5 per cent of the trees blow over during the first 10 years after death. From 20 to 40 per cent of those dead between 10 and 20 years and from 60 to 100 per cent of those dead for more than 20 years blow over. These estimates were made on girdled stands, as blight-killed areas of sufficient age were not available in the South. It is possible that under natural conditions windfall would be much less, since the dead chestnut would receive protection from the surrounding trees of other species.

Where a considerable part of the stand is chestnut, fire conditions become increasingly critical with the accumulation of bark, dead sprouts, and fallen branches at the bases of dead trees. Fires not only destroy part of the dead standing chestnut but also, on account of the intensity with which the accumulated dead material burns, frequently destroy other species in the stand. Adequate fire protection in the southern Appalachians would assist in the effort to utilize the chestnut growth and would materially prolong the life of the chestnut-extract industry.

Serious checking usually does not occur so long as the bark persists. Reference to Figure 10 shows that on the average approximately 65 per cent of the bark still remains by the sixth year after death. Checking is most rapid during the first two years after the bark has fallen. During this period several checks over 5 feet in length and 1 inch deep develop at fairly regular intervals around the trunk. The increase in size and number of damaging checks is very slow thereafter.

In addition, dead wood is liable to become brittle with long years of seasoning on the stump. It may also suffer from attacks of timber worms, resulting in lumber of lower grade. Occasionally stains are found in the wood of dead trees.

UTILIZATION OF BLIGHT-KILLED CHESTNUT

The problem of utilizing the chestnut timber from the 33,000,000 acres of the southern Appalachians, where the species represents 25 per cent of the stand, is one phase of the chestnut-blight problem which the United States Forest Service and State and extension forestry departments are endeavoring to solve.

Chestnut lends itself to the most varied usage of any timber species growing in the southern Appalachians. It is already used for extract wood, lumber, poles, ties, mine props, piles, fence posts, cordwood, and pulpwood, and it offers the possibility of increased use. Sawed chestnut lumber is much in demand, but increased cutting, because of the spread of the blight, tends to glut the market. The wood is light and easily worked. It can be used for many purposes where its coarse grain and lack of extreme strength do not make it undesirable. Its increased use for sheathing, framing, interior work, and most of all for the manufacture of boxes, packing cases, and crates, would do much to conserve other timber supplies.

Telephone and telegraph poles command the highest prices paid for chestnut. However, some purchasers demand that the poles be cut green and that they be not seriously damaged by blight, while others only specify that the sapwood be sound on the butt. For these reasons it is advisable for owners to market their poles as soon as practicable.

The manufacture of chestnut extract affords the most feasible outlet for much of the stand. Extract plants are already established strategically over the southern Appalachian district. (Fig. 12.) This industry, by far the largest consumer of chestnut, uses enormous quantities of the wood. It disposes of trees and parts of trees that are worthless except as acid wood. The limbs as well as trunks are



FIGURE 12.—A chestnut-extract plant. There are 21 chestnut-extract plants in the southern Appalachians, producing over one-half of the domestic supply of vegetable tannins

used, so that little waste remains in the woods to increase the fire hazard. Best of all, from the standpoint of the present situation, even the prolonged standing of dead timber does not exclude its use for this purpose.

Studies³ have recently been carried out, in cooperation with the Bureau of Chemistry and Soils and with chemists of the chestnut-extract plants, on the tannin content of trees that had been killed by belting or by forest fires in a number of localities in the southern Appalachians. These trees are considered fairly comparable to blight-killed chestnuts. The studies indicate that the percentage of tannin in trees dead as long as 25 to 30 years is not materially less than that in living trees. Blight-killed trees lose their sapwood and bark within a few years after their death. However, the loss of the sapwood, which is thin and has a low tannin content (2 to 4 per cent), is of little importance. Even the loss of the bark, which has approxi-

³ NELSON, R. M., and GRAVATT, G. F. THE TANNIN CONTENT OF DEAD CHESTNUT TREES. *Jour. Amer. Leather Chem. Assoc.* 24: 479-499. 1929.

mately the same tannin content as the heartwood (7 to 12 per cent), is not always a serious matter to the extract manufacturer, because peeled wood is necessary in some of the processes for utilization of the chips left after the extraction of tannin. Table 3 gives a brief guide for the utilization of chestnut.

TABLE 3.—*Condition and utilization of products from dead chestnut trees*

Number of years after tree died	Average condition of trees	Effect upon products (caused by death of tree)			
		Cordwood or extract wood	Poles (treated)	Poles and posts (untreated)	Lumber
1.....	Bark loosening and sapwood decaying on upper parts first infected.	Slight volume reductions from loss of bark in upper parts.	Nearly as good as green timber.	Nearly as good as green timber except for greater breakage in felling.	Nearly as good as green timber.
2 to 3....	Bark loose and sapwood decaying on most of tree.	Loss of sapwood and bark practically completed. Volume loss 20 per cent on large trees and somewhat more on those under 10 inches.	Usually acceptable if sapwood remains sound on the butt.	do.....	Do.
4.....	Bark and sapwood all loose.	do.....	Not suitable	do.....	Do.
5.....	Bark off most of upper parts; checking beginning on exposed areas.	do.....	do.....	Value reduced, mainly on account of checking.	Loss in value and volume from checking; gradual increases in cull from decay.
6 to 10...	Bark off; checking practically complete.	Practically no further volume loss.	do.....	do.....	Do.

BLIGHT-RESISTANT CHESTNUTS

Since direct control of chestnut blight is impracticable, the discovery of suitable strains of chestnut resistant to the disease is highly desirable. Individual native chestnuts differ in susceptibility to attack, but search for many years has shown that the number of trees actually surviving in regions where blight has been present the longest is very small. Some of these trees are being propagated and studied further with the hope of developing a strain of American chestnut sufficiently resistant to reach maturity in the presence of the disease. The numerous living trees occurring on tracts recently killed by blight are generally disease escaping rather than disease resistant. For this reason search for resistant specimens is profitable only in areas where all but very exceptionable chestnut trees have been dead from the disease for a number of years. Reports of unusually resistant trees—those that have not been severely injured by the blight—are desired. The Office of Forest Pathology records all such trees reported and inspects them as field work permits.

For a number of years after the chestnut trees in different localities were killed by the blight, the sprouts rarely reached a diameter of more than a few inches before they in turn were killed. Some sprouts now become much larger and frequently produce viable nuts before being killed by the blight. Other sprouts continue to grow and produce nuts in spite of the blight cankers on their stems. Just what will be the ultimate result of this struggle between host and

parasite can not be definitely stated, though it is reasonable to expect that by selection among the seedlings growing from the nuts of the sprouts a quick-fruited, moderately resistant strain of the American chestnut will finally be evolved.

Many owners in different parts of the country have written to the Department of Agriculture at Washington for advice on how to keep their chestnut sprouts alive. Whether sprouts should be treated or not is a question that the individual owner must decide, but in nearly all cases treating sprouts is a waste of time and money. Treatments have to be repeated, and as the trees become larger the cutting out of new infections becomes increasingly difficult. In most cases it is to be expected that the disease will finally kill the sprout or tree. The same expenditures made in planting and caring for Asiatic chestnut



FIGURE 13.—An exotic chestnut tree, valuable for its beauty, shade, and edible nuts. The blight was cut out about five years ago, and it has not reappeared.

trees will yield better returns in both nuts and shade. Figure 13 shows the effect secured with an exotic chestnut. To those who wish to work with the American chestnut for sentimental reasons, or because the sprouts are growing at hand on their land, suggestions for treatment will be sent upon request.

A number of strains of the Asiatic chestnuts have been brought to the United States by the Office of Foreign Plant Introduction⁴ in the hope of obtaining a tree which will thrive despite the chestnut blight. None of the trees so far imported and tested have proved immune, but the Japanese chestnut (*Castanea japonica* Blume) and the hairy Chinese chestnut (*C. mollissima* Blume) (fig. 14) have considerable natural resistance to the disease. Private individuals

⁴ GALLAWAY, B. T. THE SEARCH IN FOREIGN COUNTRIES FOR BLIGHT-RESISTANT CHESTNUTS AND RELATED TREE CROPS. U. S. Dept. Agr., Circ. 383, 16 p., illus. 1926.

have introduced Asiatic chestnuts, a large number of which are known to have survived the blight in various parts of the country, and reports of others are desired. Strains of these oriental chestnuts show marked differences in susceptibility, and it may not be practicable to control the blight on some of the very susceptible ones.



FIGURE 14.—A 17-year-old tree of the hairy Chinese chestnut growing at Bell, Md. This tree produced over a bushel of sweet nuts of good size in 1928, but only 2 quarts in 1929

However, most of the oriental trees can be saved by systematically cutting out any cankers that may appear and then painting the wounds. If the trees are kept in a vigorously growing condition, usually very little cutting out of cankers is necessary. Detailed information will be supplied by the Office of Forest Pathology, United States Department of Agriculture, to anyone interested in treating such trees.

Most of the imported chestnuts so far tested have been suited for orchard or ornamental purposes rather than for timber production. R. K. Beattie, of the Department of Agriculture, has been in Asia for the past two years securing nuts from the most promising trees of the forest types. Many thousands of seedlings from these forest trees are now growing in nurseries in the United States. These Asiatic chestnuts have shown marked resistance to the blight under



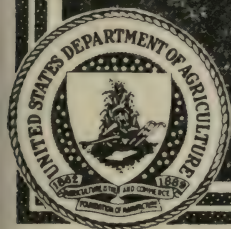
FIGURE 15.—Two-year-old coppice sprouts of hairy Chinese chestnut

the climatic conditions of their native home, and it is to be expected that they will prove resistant in this country. They do not grow so tall or straight as the American chestnut grows, but it is hoped that in addition to providing a home supply of nuts for the farmer some strains will prove suitable for small telephone poles, fence posts, and extract wood. Many strains of them coppice readily, as shown in Figure 15. Preliminary analyses of the wood of these Asiatic chestnuts indicate that it contains as much tannin as that of the American chestnut, if not more.

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1642

CHALCID CONTROL IN ALFALFA-SEED PRODUCTION



U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF ENTOMOLOGY
WASHINGTON, D. C.
1931

THE CLOVER-SEED CHALCID is a small wasp-like insect which has become a serious pest of alfalfa seed in the western part of the United States. This bulletin contains a brief account of the life history and habits of the chalcid and of the nature and extent of its damage to the alfalfa-seed crop. Investigation and experience have shown that the losses caused by this insect are greatly reduced when the practices described and recommended herein are put into effect by alfalfa-seed producers.

This bulletin is a revision of and supersedes Farmers' Bulletin 636, The Chalcis-Fly in Alfalfa Seed.

Washington, D. C.

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CHALCID CONTROL IN ALFALFA-SEED PRODUCTION

By V. L. WILDERMUTH, *Senior Entomologist, Division of Cereal and Forage Insects, Bureau of Entomology*

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INTRODUCTION

THE CLOVER-SEED CHALCID¹ (fig. 1, *a*) has for years been one of the most serious factors in reducing the annual crop of alfalfa seed in many parts of the seed-producing areas of the country.

Various investigators have been studying this pest in an effort to work out some definite plan for checking the damage caused each year. In 1914 the department published a bulletin, *The Chalcis Fly in Alfalfa Seed*, reporting the results of some of the preliminary investigations, and in 1920 a more complete bulletin, *The Clover and Alfalfa Seed Chalcis Fly*, was published on the detailed life-history studies of the insect. Since these dates much additional information has been acquired, and certain cultural methods have been developed whereby an individual farmer or a group of farmers may greatly reduce the losses caused by this pest.

The problem has not been completely solved, and certain lines of investigation are still being conducted which, it is hoped, eventually will make possible a still more definite procedure for controlling the insect if not entirely preventing the major portion of the damage.

A discussion dealing with the control of this chalcid in the alfalfa seed producing sections of the United States must necessarily be of a general nature because the conditions of climate and field operations vary so greatly in the different localities. It is believed, however, that the information given in this bulletin will assist

¹ This insect is also called the clover-seed chalcis-fly, and in the western part of the United States it is commonly known as the alfalfa-seed chalcis fly. It is known scientifically as *Bruchophagus funebris* Howard; order Hymenoptera, family Eurytomidae.

greatly in enabling a seed producer to prevent a portion of the loss caused by this pest.

DISTRIBUTION

At present the clover-seed chalcid occurs to a greater or less extent in practically every locality where either red-clover or alfalfa seed is produced. It seems to reach its greatest numbers in irrigated sections in the Western and Southwestern States where alfalfa seed is a crop of considerable importance. It also occurs in destructive numbers in the large alfalfa-growing areas in the Mid-Western States. Alfalfa seed imported from many foreign countries, including Germany, Turkestan, Chile, Turkey, and Siberia, has contained this insect.

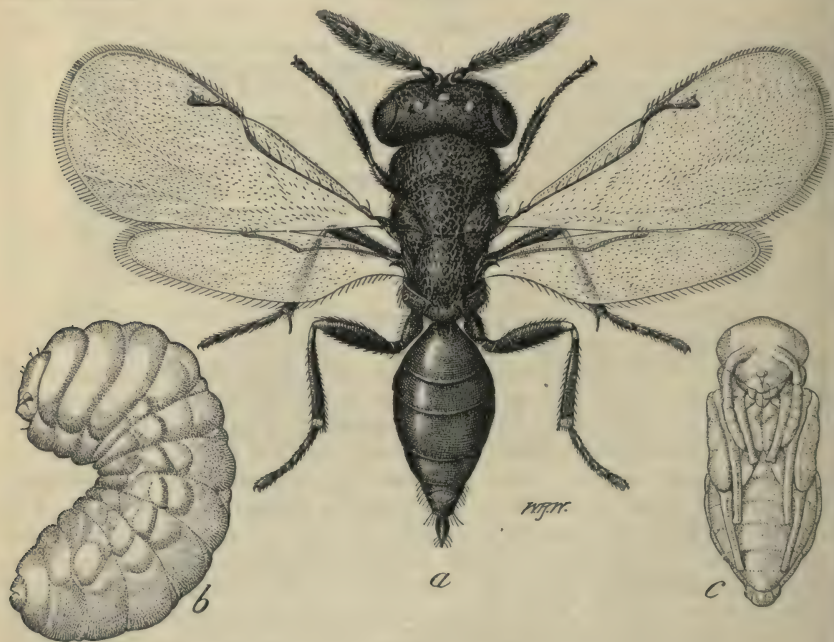


FIGURE 1.—The clover-seed chalcid: *a*, Adult; *b*, larva; *c*, pupa. Adult about thirty times natural size; larva and pupa about twenty-five times natural size

MEANS OF SPREAD

It seems possible that this chalcid is a native of the United States, as it was originally described from this country. The spread of the insect, however, has been hastened by the shipment of infested seed from one district to another. There is a heavy trade in alfalfa seed over the United States, and seed from badly infested districts is constantly being shipped to other sections. Such shipments nearly always contain infested seeds inclosing hibernating larvæ; consequently, under present methods of seed distribution, the pest has rapidly become established in all alfalfa-seed districts.

The insect, being a strong flier, often ascends high in the air over an alfalfa field and is wind-blown to neighboring alfalfa fields, and the spread in any one locality is dependent largely upon wind.

Seed pods are also doubtless carried by mountain streams or rivers and are then lodged in irrigated fields, where the insects emerge and infest the alfalfa growing there.

EXTENT OF INJURY

The loss occasioned by the chalcid in alfalfa seed is of large proportions, and it is hard to estimate for the seed-producing areas taken as a whole. The extent of damage is influenced by many different factors and is not constant from one year to another. From records made by various workers it has been found that from 2 to 85 per cent of the alfalfa seed may be infested in any given crop, and this infested seed is of course always lost. In some fields the loss may amount to less than 30 pounds of seed per acre for the year, while in other fields, possibly in the same locality or in different localities, the loss may run as high as 300 pounds per acre.

An example of the injury caused by this insect is taken from the records of Arizona for 1927. That year 22,000 acres were devoted to alfalfa-seed production in the State. Accurate counts and records were made of a great majority of the alfalfa-seed fields, and it was estimated that the loss sustained was approximately 70 pounds for every seed-producing acre in the State, which meant a loss of over 1,500,000 pounds of seed. When it is realized that this State produces about 10 per cent of the total of alfalfa seed produced in the United States and that the insect occurs in damaging numbers in many of the other districts, it can be realized that a large loss is occasioned each year by the work of this pest.

A great many seed growers do not appreciate the damage that this insect is causing because of the fact that its work is carried on within the growing seed. At harvest time, when a poor seed yield results from what appeared to be a well-podded crop of alfalfa, they do not realize that the chalcid-infested seeds, which have blown over with the screenings and have disappeared in threshing, have reduced their crop yield. Therefore it would be well for seed growers to watch closely their alfalfa-seed crop and to look for the emergence holes in the seed pods; then, by shelling out a number of these pods and looking for the dark-brown seeds or the seeds with holes in them, they will be able to estimate something of the damage to be expected. Figure 2 shows a sample consisting of 2,000 alfalfa seeds from an alfalfa field where 78 per cent of all the seeds were infested by the chalcid. This 80-acre field produced 60 pounds of recleaned alfalfa seed per acre, but the infested seed amounted to 202 pounds per acre, which, at the then current price of 17 cents per pound, meant a loss of more than \$2,700 for the 80 acres. In a given locality the loss from this chalcid is usually much greater in late-maturing crops than in early-maturing crops. This is largely due to the fact that as the season advances the insect increases in numbers. Exceptions to this rule are often noticed where parasites, which will be discussed later in this bulletin, have reduced the number of chalcids. The early alfalfa pods found along ditch banks or fence rows are often heavily infested by larvæ of the first generation.

In seed-growing districts where bur clover is present in large quantities, the pods from these plants often shelter individuals of

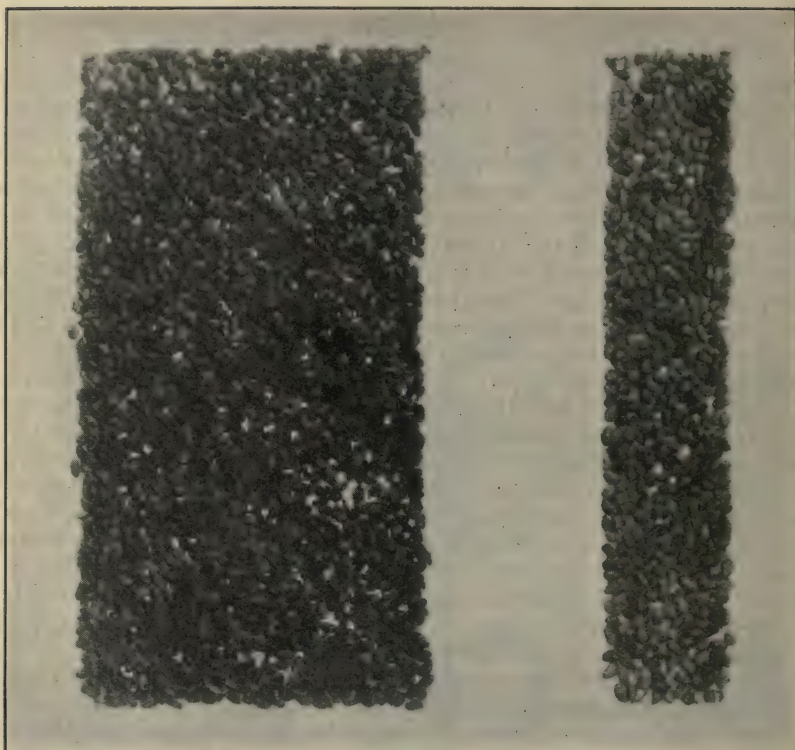


FIGURE 2.—A sample of alfalfa seed containing 2,000 seeds, 78 per cent (at left) being infested or destroyed by chalcid larvæ. About one and one-fourth times natural size



FIGURE 3.—A comparative view of alfalfa seeds: A, noninfested seeds; B, infested seeds containing larvæ; C, empty seeds from which chalcids have already emerged. About twice natural size

the first generation and in this way greatly complicate the problem of alfalfa-seed production.

TYPE OF INJURY

This insect injures the seed of alfalfa, bur clover,² and red clover, but does not in any way affect the growth of these plants for forage or hay. It is only when an attempt is made to produce seed that damage is noticed. A seed that is infested by a chalcid larva is an entire loss to the seed grower. The infested seed becomes very dark brown, at times nearly black (figs. 3, B, and 4), and lacks the luster that is characteristic of a healthy uninfested seed. A seed from which a chalcid adult has emerged is entirely hollow (figs. 3, C, and 5) and shows the round hole from which the adult insect has escaped. These seeds are blown over with the screenings when the seed crop is threshed or hulled. The alfalfa and bur-clover pods (fig. 6) show round exit holes like those in the seed, and these holes are usually located directly over those found in the seed inside.



FIGURE 4.—Infested alfalfa seeds containing the hibernating larva of the chalcid. About twelve times natural size. (Urbahns)



FIGURE 5.—Alfalfa seeds which have been hollowed out by the larvæ and from which the adult chalcids have emerged. About twelve times natural size. (Urbahns)

² Bur clover is of two kinds, known scientifically as *Medicago hispida* Gaertn. and *M. hispida denticulata* (Willd.) Urban.

STAGES OF THE INSECT

All stages of development of this insect are completed within the infested seed.

The adult deposits a single, minute egg, invisible to the naked eye, through the soft green seed pod directly into the soft developing seed. The eggs are deposited while the seed pods are from one-fourth to one-half grown, at which time the seeds within are small watery particles showing very slight development. The eggs hatch in from 3 to 12 days, depending upon the temperature at the time development is taking place.

Under average temperature conditions the larvæ (fig. 1, *b*) begin their feeding a day or two after hatching. These larvæ continue feeding within the tender growing seeds, and most of them have completed their growth by the time the pods have ripened. When these

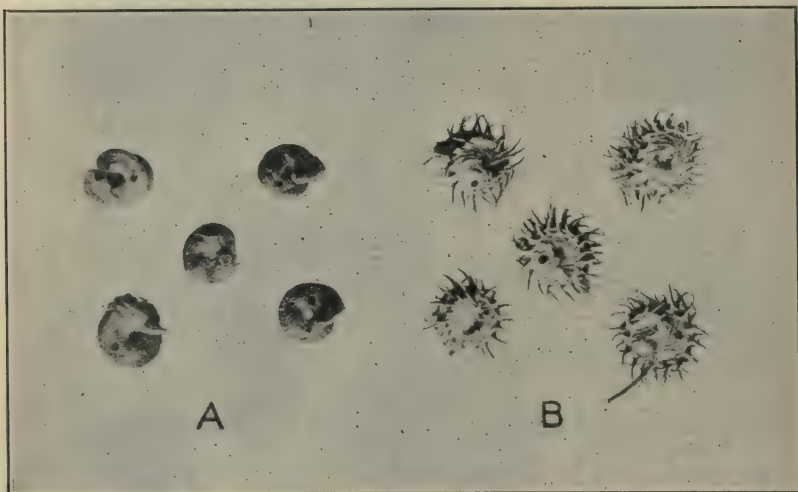


FIGURE 6.—Alfalfa pods (A) and bur-clover pods (B) showing the exit holes made by the adult chalcids. About three times natural size

larvæ have completed their development, provided there is sufficient moisture remaining in the seed pods and the temperature is sufficiently high, they transform to the pupal stage (fig. 1, *c*), and after resting for a period of from 5 to 40 days the insects emerge as winged adults. In cases where the seed pods have already become dry and ripe or where the temperature has become low, owing to the approach of fall, the larvæ may remain for an indefinite period within the hollowed-out seed until both temperature and moisture are favorable for their changing to the pupal stage.

The adult chalcid (fig. 1, *a*) emerges from the pupal stage as a small black insect resembling a tiny wasp. It gnaws its way out through the shell of the seed, then gnaws a hole through the seed pod (fig. 6), and comes out through this opening, leaving the destroyed, empty seed behind. It is then ready for feeding and mating, and egg laying in other susceptible seed, thus continuing the destruction indefinitely.

SEASONAL HISTORY

The seasonal history of this insect varies greatly in the different sections of the country. This variation is due largely to differences in climate.

In the warm irrigated valleys of the Western and Southwestern States the adults emerge from hibernation quarters early in the spring, often as early as March. Egg laying starts as soon as either bur clover or alfalfa pods are of sufficient size, and a continuous series of generations are carried through the summer upon developing seeds. These generations follow one another every 30 to 40 days throughout the season and sometimes continue until late in November before the insect again goes into hibernation.

In the Middle Western States and in the colder northern areas the adults from hibernating larvæ may not emerge until early June, and each succeeding generation requires a much longer period for development; consequently there are only one or two generations, possibly three, during the season.

In southern Arizona, where the mean temperature for the season is well above 80° F., as many as six generations have been observed; while in the Uintah Basin of northern Utah, where the mean temperature during the alfalfa-seed producing months falls much below this, as few as two generations have been observed.

This difference in the number of generations naturally has a considerable effect upon the percentage of infestation sustained by alfalfa-seed crops in the various districts. However, the effect of the number of generations is less marked than would seem probable, because of the relation of insect parasitism to the chalcid problem. It so happens that in the warmer districts the parasites are able to develop nearly as rapidly as the chalcids themselves, hence the parasitic destruction of chalcids is greater in these warmer valleys, and frequently the injury to seed is reduced to a greater extent by these parasites in the warmer sections than in the colder ones. Therefore, owing to these counter influences, the percentage of damage remains nearly the same in all these sections in spite of varying temperature conditions.

HIBERNATION

The chalcid passes the winter in the hibernating condition, as a larva within alfalfa seed. These larvæ are found in seeds on the ground in alfalfa fields or along fence lines and ditch banks throughout the season. A great number of seed pods or seeds are found on the surface of fields where seed crops have been removed the previous year. Screenings around alfalfa straw stacks and the seeds of bur clover contain many hibernating larvæ. Therefore, it may be readily understood that the destruction of these seeds is one of the logical and simple means of reducing the damage caused by the insect. This subject is discussed more fully under the heading of control measures recommended for this pest.

HABITS OF THE INSECT

The chalcid adults are most active in warm weather, but often seek shade in the heat of the day. They are frequently seen in con-

siderable numbers flying over alfalfa-seed shocks or swarming over the mower or driver when the seed crop is being cut. Ranchers often complain of their getting into the eyes, and frequently they confuse them with gnats. The writer has observed them to be so numerous in the air over a roadway adjoining an alfalfa field that a man's clothing would soon become covered with hundreds of the little black insects. The adults apparently feed in the alfalfa blossoms, and many remain alive for several weeks where conditions are satisfactory. In the warm, irrigated fields of the Southwestern States, where excessively dry conditions prevail in midsummer, many of the larvæ developing within the seeds go into a resting stage scientifically known as *æstivation*: in this condition they may remain in the dried seeds for a period lasting one or even two years. If these seeds are distributed during that time by man or through natural agencies to other localities, the adults upon issuing infest alfalfa-seed fields in such places. This makes the control problem more complicated.

NATURAL ENEMIES

The chalcid larvæ in many cases are destroyed by small parasitic insects of about the same size as the chalcid itself. In many alfalfa-growing sections these parasites often reduce the numbers of the chalcids to such an extent that the damage is not nearly so great as it would be if the parasites were not present. These little insects lay their eggs within the seeds already infested with the chalcid larvæ, and the parasitic larvæ entirely consume the developing seed pest. There are ten kinds of these parasites already known as destroying the chalcid larvæ, but only three of these exert any great influence in their control.

CONTROL MEASURES

The control of the clover-seed chalcid is extremely complicated because of the many varying conditions under which the insect is encountered, its widespread distribution, its habits of development, and its remarkable ability to maintain itself. The conditions under which it is found are often extreme as regards climate, soil, and cultural practices, and any proposed control measures must be adapted to meet them. Fortunately, however, many methods for reducing the numbers of this pest are known, and these, if properly used, will save the ranchers much loss in many localities.

In the paragraphs that follow the known means of reducing the damage from this pest are outlined.

CULTIVATE ALFALFA IN FALL AND WINTER

It has already been shown that much loose seed and many seed pods containing chalcid larvæ fall to the ground during the process of harvesting, and these overwintering forms give rise to the following year's infestation. Under Arizona conditions the larvæ in these seeds can readily be destroyed by thoroughly cultivating an alfalfa-seed field at some time during the fall or winter. The covering of the seed and the exposure to moisture cause the infested seed to mold and decay, thus destroying the hibernating larva. An alfalfa culti-

vator, a disk, or a spring-tooth harrow are the best implements for doing this work. The seeds need not be covered to a great depth to destroy the larvæ within, but at least 2 inches of the topsoil should be disturbed. The time for this cultivation will depend largely upon the farm practices of the rancher concerned. In case the stand of alfalfa is very thin and it is desired to seed one of the small grains, such as barley or oats, in the alfalfa field, this cultivating can be done in the early fall. On the other hand, if the alfalfa-hay crop is not to be supplemented by the addition of a small-grain crop, the cultivation may take place later in the winter.

CLEAN UP FENCE LINES, DITCH BANKS, AND WASTE PLACES

In winter cultivations, an effort should be made to cover as much of the field as possible. This should include the ditch banks and as much of the fence line as can be reached with the cultivator.



FIGURE 7.—An alfalfa-seed field with check ridges and fence lines burned over to destroy the hibernating larvæ of the chalcid. (Urbahns)

When this cultivation is completed, all remaining areas should be cleaned up and burned over. (Fig. 7.) Ditch banks can often be better cultivated after burning than before. Irrigation ditches often need to be rebuilt each year, regardless of the benefits to be derived from eliminating hibernating chalcids. The cleaning of fence rows and other waste places, however, should not end with the winter operations but should be continued throughout the season. The first generation of the chalcid is often allowed to develop unmolested along the borders of an alfalfa field or along ditch banks (figs. 8 and 9), and these breeding places serve to reinfest the entire field when the alfalfa seed is starting to mature. If one or more hay crops are removed before allowing the seed crop to develop, the uncut alfalfa should be destroyed after each cutting and not allowed to go to seed. Some ranchers follow the practice of pasturing the early alfalfa in the spring instead of cutting for hay, and this often results

in a high seed yield and low chalcid infestation. This low infestation is probably due to the fact that all the alfalfa growing in waste places is eaten off and seeds are not allowed to develop and harbor an early generation of the insect. An admirable method, one which



FIGURE 8.—The ditch bank, $3\frac{1}{2}$ rods wide, with its neglected alfalfa, was a place of breeding and hibernation for the chalcid—a source sufficient for the infestation of surrounding fields. (Urbahns)



FIGURE 9.—The rank growth of dry alfalfa shown on this ditch bank was loaded with infested seed pods in which a multitude of chalcid larvæ were hibernating. (Urbahns)

not only destroys chalcids but also saves much time and labor, besides killing weed seeds and other insect pests, is the practice of fencing all ditches and ditch banks and then destroying uncut alfalfa by pasturing with either sheep or cattle.

CLEAN UP STACK YARDS, SCREENINGS, AND WASTE

In alfalfa-seed growing districts one may often see alfalfa straw stacks (fig. 10) around which the screenings have been left throughout the winter and early spring, without any attempt to clean up the threshing grounds. This is a big mistake. If the straw stack is to be used for feed, it should be entirely consumed before the weather is warm enough to allow the chalcids to emerge. All the screenings around these stacks should be cleaned up so thoroughly that no sign can be found of even the location of last year's threshing operations. In this way infestation can be kept down. If this is not done, all other measures may be rendered ineffective.

DESTROY ALL BUR CLOVER

As has been previously mentioned, bur clover in many localities grows abundantly in alfalfa fields and along ditch banks surround-



FIGURE 10.—An alfalfa straw stack, showing the ground covered with screenings in which many chalcid larvæ were hibernating. (Urbahns)

ing such alfalfa fields. In these localities the chalcid develops an entire generation in the seeds of these wild plants before seed pods have started to develop on alfalfa in the fields. Under such conditions all bur clover should be destroyed before its seed pods complete their development. Bur clover can best be destroyed by cultivation in late winter or early spring or by pasturing or burning over the fence lines, ditch banks, and other waste places.

STACK DELAYED CROPS

If it is intended to delay for any length of time the threshing of alfalfa after it is harvested, it should be stacked in large, well-placed stacks rather than allowed to lie on the field in small bunches, as many adult chalcids are likely to issue from it soon after cutting. In this case they serve to reinfest neighboring fields or alfalfa grow-

ing in waste places, and thus assist in increasing the chalcid population. Frequently a rancher may discover that a field is severely infested and may attempt to save a portion of the forage value of the crop by pasturing the field. (Fig. 11.) This should not be



FIGURE 11.—A severely infested alfalfa-seed field which had been abandoned. Infested pods cover the ground, where they offer favorable conditions for the hibernation of the chalcid. (Urbahns)

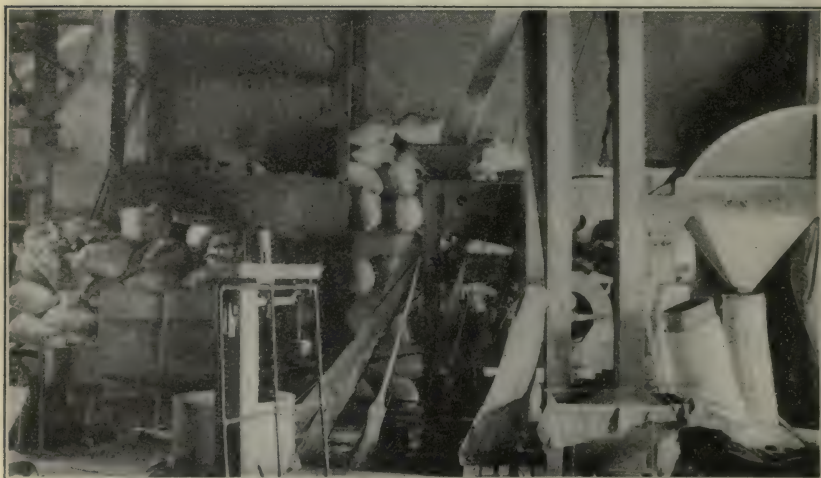


FIGURE 12.—Interior view of an alfalfa-seed cleaning plant, where the infested seeds, together with weed seeds, are removed before the product is sold for planting. (Urbahns)

done, because it results in scattering the infested seed and seed pods by the animals in the field; instead, the crop should be harvested for hay and well stacked, so that the sweating process will kill a great majority of the chalcids that are still within the seed.

PLANT CLEAN SEED

In sowing alfalfa, it is important to use only the best recleaned seed. Most of the seeds containing chalcid larvæ can be removed by thoroughly recleaning all alfalfa seed before planting. The cleaning of alfalfa seed to remove infested seeds and weed seeds can be done with a small fanning mill, but as a rule the results are more satisfactory if the work is done in a well-equipped seed-cleaning plant. (Fig. 12.) Many farmers in alfalfa-seed districts practice the sowing of a grade of seed known as "thresher-run" seed, which may have been grown on their own fields or may have been purchased from another locality, but is used with the idea of effecting a saving in the cost of alfalfa seed. The use of such seed, which sometimes contains infestations as high as 10 to 25 per cent, results in a poor stand, and the hibernating chalcid larvæ soon give rise to a new generation of chalcids in the seed field. This practice of using uncleaned seed is one that should be abolished everywhere, as it can not be justified by any consideration.

ADOPT UNIFORM PLAN FOR HARVESTING THE SEED CROP IN EACH LOCALITY

Each locality should, through some interested organization, work out a uniform plan for producing and harvesting alfalfa-seed crops. This plan, besides observing the recommendations given, should be arranged after consideration has been given to certain factors which are rarely constant for any two alfalfa-seed producing districts of the United States. The points to be considered are: The time of starting the seed crop in the spring, the time of cutting the seed crop as regards maturity, and whether one or two seed crops per year are most desirable for the given locality.

In each locality the time of starting the seed crop in the spring should be uniform. Very frequently it happens that one rancher takes off one hay crop and allows the next crop to go to seed, while his neighbor cuts two hay crops and allows the third growth to go to seed. This means that the chalcids which escape from the early seed crop of the first rancher will infest the later seed crop of his neighbor; the cycle is thus continued year after year and the injury caused by the infestation greatly increased. The question of which procedure should be practiced must be left to the decision of each community.

Provided the soil and moisture conditions are satisfactory, an alfalfa-seed crop should be hurried through to maturity, immediately cut, and threshed as soon as dry. The seed crop should be handled in such a way that the seed will mature at approximately the same time. This can usually be accomplished by practicing thorough spring irrigations, thus furnishing a reserve of moisture in the subsoil that will be available for the seed crop later in the season. Under this method the alfalfa plants will come to full podding at the same time instead of bearing a mixed irregular setting of seeds such as results from later irrigations. This will prevent much infestation. Often, however, because of the lack of ideal fruiting conditions, a stand may fail to set a heavy crop of seed, and then it seems necessary that a top crop be allowed to develop and that cutting be

delayed from two to three weeks. This procedure, while often giving a high seed yield, will greatly increase the percentage of infestation and will assist in distributing the chalcid pest for another year. In many cases where a high seed yield is secured by this method it is because parasites, as mentioned in a previous paragraph, have controlled the chalcids. Whether or not this procedure should ever be practiced depends on a careful examination of the field, either by the grower or by some other well informed person. In case a heavy infestation is found in the early pods the field should be harvested for seed or cut for hay. In case infestation is found to be light or entirely lacking the growth can be allowed to continue and the crop cut at a later date.

The number of crops of seed produced in different localities will vary. In the warm southwestern irrigated valleys, especially in southern Arizona and in California, an attempt is often made to produce two crops of alfalfa seed in the same year. This sometimes produces a very satisfactory total yearly yield, but the second crop in practically all cases is more heavily infested with chalcids than is the first one, and the procedure thus becomes a detriment to alfalfa-seed production as a whole. Also it is likely to result in a reduction of the first crop of the following year that is great enough to more than offset the gain which seemed to have been made by harvesting the second crop the previous fall.

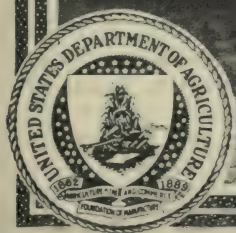
ORGANIZE EFFORT AND PRACTICE COOPERATION

While it is recognized that much can be accomplished by an individual farmer if he will follow the control methods outlined in the preceding pages, yet final and complete success can come only through the cooperation and organized effort of the alfalfa-seed growers in any particular locality. Unless this is done, the efforts of an individual may be greatly counteracted by the faulty practices of a neighboring seed grower. One of the first duties of an alfalfa-seed growers' organization should be that of maintaining a warehouse or seed-cleaning plant (fig. 12) where nearly all infested seeds may be removed before the product is placed on the market and where weed seeds and foreign matter may also be cleaned out in order that the product may command high market prices.

U. S. DEPARTMENT OF
AGRICULTURE

FARMERS' BULLETIN No. 1643

FIRE SAFEGUARDS FOR THE FARM



THIS BULLETIN tells how to avoid or lessen the fire hazards on the farm and thereby add to the safety of property as well as persons. It points out how the individual farmer can further reduce the probability of serious fire losses by means of simple home equipment with which a fire that is discovered in its beginning stage can be quickly extinguished. Finally, it points out the need for organized and well-equipped rural fire departments and tells how this need has been met in many rural communities. Such organized protection is necessary for the farmer in order to hold the loss to a minimum whenever a fire gets a threatening start.

Reasonable care and forethought in the removal of needless fire dangers, a fair degree of individual preparedness, and the availability of community fire protection will greatly reduce the present fire losses on American farms, which now total about \$100,000,000 per year. Substantial reduction in the number and destructiveness of farm fires, which often destroy human life as well as property, will eliminate much unnecessary hardship and sorrow and will help to promote rural progress and well-being.

This bulletin supersedes Farmers' Bulletin 904, Fire Prevention and Fire Fighting on the Farm.

FIRE SAFEGUARDS FOR THE FARM

By V. N. VALGREN, *Senior Agricultural Economist, Division of Agricultural Finance, Bureau of Agricultural Economics*; HARRY E. ROETHE, *Engineer, Chemical Engineering Division, Chemical and Technological Research, Bureau of Chemistry and Soils*; and M. C. BETTS, *Senior Architect, Division of Agricultural Engineering, Bureau of Public Roads*

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INTRODUCTION

THREE KINDS or classes of safeguards are required to make farm property reasonably safe from fire. By the proper application of these safeguards the annual farm fire loss could be reduced by \$50,000,000 or more. Even this reduction would merely cut in half the present annual loss of about \$100,000,000. Students of fire prevention and protection are generally agreed that considerably more than half of the farm fires that occurred last year or in earlier years, could readily have been prevented. The further fact that accidental fires, both on the farm and in the city, frequently destroy human life as well as property makes the problem of fire safety doubly important.

The first of these safeguards is the exercise of care and forethought in the construction, maintenance, and use of the property, with a view to eliminating, so far as possible, all needless fire danger. The second is individual or home preparedness in the form of simple equipment for use in extinguishing fires before they reach serious proportions. The third is community preparedness, consisting of a fire-fighting organization equipped to check larger fires or to prevent their spread to buildings other than those in which the fires originate. Such an organization, with more effective equipment than the individual farmer can maintain, is needed to hold the loss to a minimum in those cases in which the first two classes of safeguards have failed or threaten to fail.

These three classes of safeguards together make a triple line of defense against destruction by fire, each class supplementing the other two. The order in which they have been given may be said to be the order of their importance as well as the order in which they should be applied. The first class of safeguards really consists of means and methods of avoiding fire danger, and constitutes fire prevention.

The second and third are means and methods of fire fighting, or fire protection as it is usually called.

Without the exercise of care and forethought in prevention, fires are likely to occur so frequently and to spread so quickly that no form of protection will prevent serious losses. Without individual preparedness by means of simple fire-fighting equipment, most of the fires that do occur are likely to result in serious losses. Without community equipment and organization, a fire that is not promptly stopped by the use of home equipment is likely to destroy not only the building in which it originates but near-by buildings and other property.

If the first and second of these sets of safeguards, or either of them, could be made perfect, the need for the third—organized or community fire protection—would disappear. But such perfection never has been reached, in America or elsewhere. Furthermore, it is admitted that complete fire safety by individual action or even by combined individual and community action is probably an unattainable goal.

Reasonable preventive measures, and reasonable preparedness against such fires as may occur, are all that can properly be recommended or practiced. Beyond such rational limits, measures for fire prevention and protection become unduly costly or burdensome. No one would recommend, for example, that heat and light be dispensed with in the home because they can not be made absolutely free from danger of fire, or that fire-fighting forces and equipment should be maintained by farmers on the same elaborate scale that prevails in congested and high-value city districts. With moderate and practical preventive measures the probability of serious loss by fire to the individual farmer can be greatly reduced. In fact, property and persons can be made reasonably safe against loss or destruction by fire without resorting to extreme measures, and when these reasonable precautions have been taken by a community, insurance against such infrequent losses as may occur should be obtainable at very moderate cost.

But how many farms or how many rural communities in the United States are now safeguarded against fire to a reasonable degree? The cost of fire insurance in many parts of the country and the estimates of our total farm fire loss give a rather distressing reply. No complete or highly reliable figures for our annual farm fire losses are available. Private estimates vary from \$60,000,000 to \$150,000,000. Such official reports and figures as are available suggest that an estimate of \$100,000,000 would come fairly close to the actual losses of farm property as distinguished from the broader concept of rural property. This estimate was recently approved by the committee on farm fire protection of the National Fire Protection Association.

Commercial farm-insurance rates for limited sections of the country reach \$2 per \$100 per year under certain conditions. Even for sections or States in which fire insurance in farmers' mutual companies can be obtained at an average cost of about 20 cents per \$100 per year and in which commercial rates are only a little higher, there is good reason to believe that the farm fire losses are fully twice what they would be if moderate and rational safeguards against fire

were employed by all farmers. Here, as in districts less fortunate from a fire-loss standpoint, the added personal safety and the removal of much of the worry and privation that accidental fires usually bring in addition to the direct fire loss, would represent as important gains as would the savings from a reduced cost of insurance.

ELIMINATION OF FIRE DANGER

In the first class of safeguards, or measures for the elimination of fire danger, the questions and problems involve considerations of safe construction, proper maintenance, and due caution in the use of heating, lighting, and other equipment and materials that involve danger to property and life.

CONSTRUCTION AND MAINTENANCE

Location of building.—The first question in connection with the construction of a building is the location of the building with reference to other buildings on the farmstead. The barn, or barns, in which hay and straw are stored and used, and about which some litter is at times unavoidable, should normally be separated from the dwelling wherein fire is regularly used, by a distance of at least 100 feet. A clear space of 150 feet is held to give practical security from exposure fires. Where other considerations make such spacing of the buildings impossible or inadvisable, special consideration should be given to other protective measures, such as the use of non-combustible or fire-resistant construction materials, by means of which the hazards due to proximity of these buildings to one another can be partially offset.

Another important consideration is that of so placing the main buildings, particularly the dwelling and the barn, that the prevailing winds in the locality blow at right angles to a line connecting these buildings, rather than parallel to such a line. If the dwelling and barn are so placed that the prevailing winds blow along the line connecting them, the fire hazard is materially increased. With a strong wind blowing from the dwelling to the barn, there is the danger, not only that the burning of the dwelling will seriously endanger the barn, but also that on some dry and windy day sparks from the dwelling-house chimney may set fire to the barn. With the wind blowing from the barn to the dwelling, the main danger is that if the barn should burn, the dwelling would be seriously endangered by the strong heat and the flying sparks that are particularly characteristic of a barn fire. The result might be a disaster such as that pictured in Figure 1. In addition to the fire hazard involved, a farm layout in which the prevailing winds blow from the barn or the hoghouse to the dwelling, has the objection that the dwelling will be needlessly subjected to disagreeable farmyard odors.

In few, if any, localities is the wind movement consistently from any one direction, or along a given line. Regardless of how the buildings are placed with reference to one another the wind direction at times, will be either directly from the dwelling to the barn or from the barn to the dwelling. In practically all sections, however, there is a prevailing wind direction. To ignore this fact is to

increase unnecessarily the danger of serious loss from fire and to incur other unnecessary discomfort. In a given locality, for example, the prevailing winds may be from the northwest to the southeast,



FIGURE 1.—Farm fires often leave only ashes and scrap iron

or the reverse of this direction, fully three-fourths of the time. In such a locality the farm layout, if possible, should be such that the barn is either northeast or southwest of the dwelling.

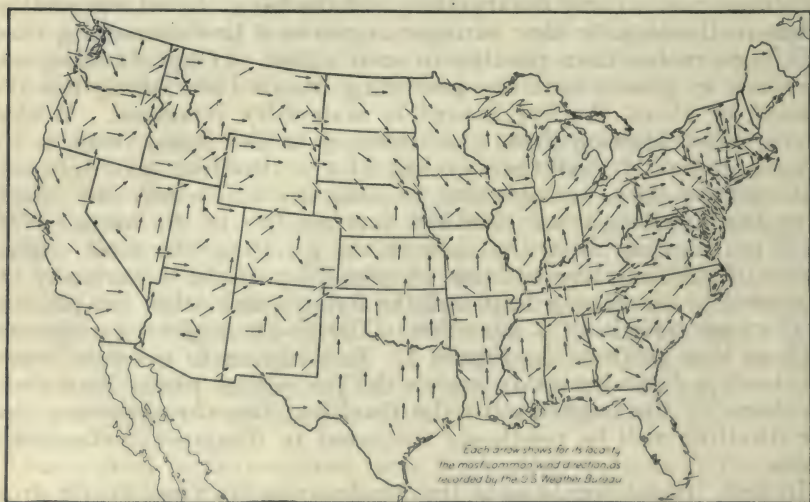


FIGURE 2.—Wind direction should be considered in planning a farm layout

The prevailing wind directions in all parts of the United States are indicated in Figure 2. The arrows indicate, for their respective localities, only the wind direction that prevails to a greater extent

than does any other. In many cases, the second most common wind direction is from the point of the compass opposite that representing the most common or prevailing direction. If the farm layout, therefore, is so planned that the line connecting the main buildings is approximately at right angles to the line of the more common wind directions, the occasions when the wind blows either from the barn to the dwelling or from the dwelling to the barn will be relatively infrequent. It is impracticable, in this bulletin to give complete information on the wind directions for all localities, but more complete information may easily be obtained. The United States Weather Bureau maintains section centers or regional head offices to which the local stations send their data for further compilation and analysis. These section centers are located at the capitals of the respective States except as indicated in the accompanying list.

State	Weather Bureau section center	State	Weather Bureau section center
California	San Francisco	New York	Ithaca
Delaware	Baltimore	Oregon	Portland
Florida	Jacksonville	Pennsylvania	Philadelphia
Kentucky	Louisville	South Dakota	Huron
Louisiana	New Orleans	Texas	Houston
Maryland	Baltimore	Washington	Seattle
Minnesota	Minneapolis	West Virginia	Parkersburg
Mississippi	Vicksburg	Wisconsin	Milwaukee
Nevada	Reno		
New England (all six States)	Boston		

By addressing the United States Weather Bureau Office at the capital city of the State, or, for the States listed, at the city named, anyone can obtain more complete information on the wind directions for his locality, including not only the direction of the prevailing wind but the percentage of the time that the wind comes from each of the commonly recognized points of the compass.

Roofing material.—The kind of roofing material to be used is of particular importance in the construction of dwellings on the farm, as elsewhere. Other buildings may shelter animals and other valuable property. The dwelling shelters the family. Heating apparatus is an essential part of the home, and effective spark arresters are not generally found on farm dwellings. It is probable, therefore, that at times sparks will fall on the roof. Failure to keep the chimney clear of accumulations of soot adds greatly to this danger. Especially on days of high wind and strong draft these soot accumulations are likely to ignite and temporarily transform the chimney into a roaring furnace. In any case, should fire originate in some other building, the roof of the dwelling may be exposed to flying brands.

A substantial roof of tile, slate, metal, or other noncombustible, fire-resistant or fire-retardant roof covering of the better grades, requires a somewhat greater initial cost than one consisting of wooden shingles or of thin roll roofings, but it adds materially to safety from fire. It also lessens the possibility of flying brands that might set fire to near-by buildings in case fire originates in the dwelling.

If wooden shingles are to be used, poor grades should be avoided, especially for dwelling roofs, and the best grades of edge-grained shingles should be insisted upon. Flimsy and cheap grades of

manufactured roofing should be avoided even though they may be found more or less fire resistant while they are in good condition. For all varieties of roofing material, the cost per year of service rather than the initial cost is the final test of economy. The danger that chimney sparks, or brands from a near-by fire, may ignite a roof that is covered with dry wooden shingles is greatly increased when the shingles are old, frayed, and warped. Roofs of other material when in poor repair also increase the danger of fire. Such dilapidated roofs on dwellings should be replaced or recovered not only to give renewed weather protection, but to remove a special fire hazard.

Fire stopping.—In the construction of walls of the dwelling fire stopping should be given due consideration. By fire stopping is meant particularly the closing of all open spaces in hollow walls at the floor line so that fire will not pass quickly from the basement to the house above, or from one story to another. The added cost of this precaution in the construction of a dwelling is small in comparison with the added fire safety that it gives.

Chimney construction.—The construction of the chimney deserves special attention, and under no circumstances should the avoidance of minor expense in the construction of this feature be permitted to make the home a fire trap. For safety in chimney construction, substantial masonry is necessary, and this should, without exception, rest firmly upon the ground and not on brackets or on any part of the building, unless a substantial cellar wall be considered such a part.

Chimneys disintegrate most quickly at the top, owing to the combined action of weather and hot gases. Lime mortar in the joints and soft brick are soon affected with the result that wide cracks are formed, permitting the passage of sparks. Such a condition is frequently found in old chimneys to a point well below the roof and constitutes a source of great danger. Minor cracks may be filled with good cement mortar, but if there are many cracks or if the bricks are eaten away the chimney should be torn down to solid construction and rebuilt with hard-burned brick and good cement mortar. A crack in a chimney may be located by building a smudge in the fireplace and covering the chimney with a board or wet sack. Escaping smoke will then quickly reveal any existing crack or cracks in the chimney walls. All new chimneys should be built with sound thick walls and preferably should be lined with fire-clay flue lining. No woodwork should be built into or in direct contact with the masonry of any chimney. Defective chimneys are one of the most frequent causes of fires in dwelling houses.

Open stairways are a source of danger in that, when a fire has started in the cellar or lower floor of a house, they may act as chimneys and may soon become impassable. Loss of life in farmhouse fires is often the result of this condition, the victims being trapped on an upper floor. A second stairway in another part of the house may mean the difference between life and death.

Barn fires are generally caused by carelessness, lightning, or spontaneous ignition. Many of the precautions recommended for dwelling construction apply to barns also; the least that should be done is to provide a heavy floor over the stock, if hay is stored above, to

prevent rapid burning through, should the hay be ignited. This will increase the opportunity to save valuable stock. All hay chutes and stairways should be closed lest a fire below spread rapidly to the hay above or burning hay from the mow drop into the stable below.

The specific suggestions regarding fire-protective construction on the farm, given in Farmers' Bulletin No. 1590, which cover chimneys as well as all other parts, should prove of much value whenever important alterations are to be made or new buildings are to be erected. A copy of this bulletin may be had free if a request is addressed to the United States Department of Agriculture.

Lightning protection.—Protection against lightning is important, as lightning is one of the more frequent causes of fire in farm buildings, in most parts of the United States. Excepting possibly a few localities in the Far West and especially in the Pacific Coast States, where the lightning hazard is unusually slight, no farm building of substantial value should be considered actually completed until it has a standard system of protection against lightning. Individuals can still be found who question the value of protection from lightning by means of a system of grounded conductors or by the proper grounding of substantial metal roofs, but the evidence of the value of such protection leaves no reasonable room for doubt.

The lightning-protection system should be inspected at least once a year, and particular attention should be given to the rods at the points at which they enter the ground. It is here that corrosion of the metal or down conductors is most likely to occur. Mechanical injury to the rods also most frequently occurs at or near the ground.

All who have looked with some care into the question of the value of protection from lightning agree that, when applied according to accepted modern methods and standards, it possesses a high degree of efficiency. This efficiency has been calculated as ranging from about 85 per cent to 98 or 99 per cent, the higher figures applying to systems that comply with present standards. A 98 per cent efficiency in this case means that the probability of loss or damage from lightning is so reduced by the protective system that only two cases of damage from lightning actually occur to protected buildings for each hundred cases of damage that occur to the same number of unprotected buildings under the same general conditions.

More detailed information regarding the value of lightning protection and methods of providing such protection is found in Farmers' Bulletin No. 1512, which may be had free, as long as the supply lasts, if a request is addressed to the United States Department of Agriculture.

Electrical installations.—Electrical installations constitute serious fire hazards unless care is used in installing the wiring, motors, and devices, and in the proper handling of the equipment. The wiring of buildings should be properly performed; otherwise a ground or short circuit may be the means of starting a fire. One of the most serious fire hazards is the use of improvised fuses or fuses of too great amperage. Open wiring should never be used in farm buildings in which flammable material is stored, as the wires are exposed and the insulation may become worn or may be gnawed by rats or mice, causing grounds or short circuits, which are likely to cause

fires. All wiring should be inclosed in conduits or other approved protective covering, and all joints should be made mechanically and electrically secure in fireproof boxes, and should be as well insulated as is the wire.

Motors and generators that have commutators or slip rings and brushes or other parts that are liable to arc during operation (that is, where the electric current may jump from one part to another) should be kept out of locations where the arcing may ignite flammable material. Switches should be kept out of such locations, and knife switches should always be installed in metal boxes. Motor starters that are liable to arc and rheostats that are likely to attain high temperatures should be kept out of rooms containing flammable material. Transformers should never be located against walls of buildings, especially wooden buildings, but should be at a safe distance, so that burning oil from the transformer will not cause a fire hazard. Rheostats and other resistance devices should always be considered as sources of heat, which are liable to become red hot and from which drops of molten or heated metal may fall or spatter to some distance. The fire and personal hazard can be avoided only by installing resistance devices with this possibility in mind.

Where there is considerable outdoor wiring, line lightning arresters should be installed to protect the buildings from fire and to protect the motors and electrical devices from burnouts.

The National Electrical Code covers interior wiring in detail. All wiring and appliances should be installed in compliance with it, and in accordance with any additional requirements that the local electric company may have. The code is a set of rules that have been the standard of practice for many years covering electrical installations from the viewpoint of fire hazard. It is revised from time to time by the electrical committee of the National Fire Protection Association. All electric wiring should be done by an experienced electrician who is familiar with the requirements of the National Electrical Code.

Many disastrous fires have been started by the careless handling of flatirons, curling irons, and similar devices. When left standing with the current on, such devices become excessively hot and may ignite wood or other flammable material. Some flatirons are provided with a thermostatic cut-out that acts to break the electric circuit when the temperature of the iron has reached some predetermined point.

HAZARDS AND DANGERS FROM CARELESSNESS

A very large percentage of farm fires are due to carelessness in the placing and in the use of heating and lighting equipment. Thousands of farm homes and hundreds of lives are lost each year because of lack of care and forethought in the selection, installation, placement, and operation of stoves, lamps, and other heating and lighting apparatus.

Stoves and furnaces.—Stoves and furnaces should be put up solidly and should be so placed that the heat from them can not ignite near-by walls or woodwork of any kind. If the room is such that it does not permit placing the stove at sufficient distance from the walls to avoid danger to exposed woodwork, the wall should be

covered with sheets of metal or asbestos. A substantial metal or asbestos covering should also be placed under the stove, and this protective covering should extend well out beyond the edge of the stove, particularly on the side containing the door to the fire box, from which burning embers are likely to fall.

Stoves or furnaces should be of such size that sufficient heat can be generated to keep the home at the proper temperature even in cold weather without crowding or overheating them. This precaution adds greatly to the life of the apparatus as well as to the fire safety of the dwelling.

Stoves and pipes, as well as chimneys, should be cleaned from time to time by the removal of all accumulations of soot. In the absence of any better device for sweeping the chimney, a bundle of twigs or of branches of evergreen tied to a rope will be found relatively effective. Even a bundle of coarse hay, the wisps of which are well twisted together, makes a usable brush for sweeping the chimney. Specially constructed wire-brush chimney cleaners have also been devised.

Stovepipes.—Stovepipes should enter directly into the chimney without passing through walls or partitions. If a house is so constructed that the chimney can not be reached without passing the stovepipe through a wall except at considerable expense, a ventilating thimble should be provided. This thimble, which may be obtained at almost any hardware store and fitted into the wall or the floor, greatly reduces the danger of fire from an overheated pipe, since air circulates through the open spaces in the thimble on all sides of the pipe and carries off the heat to a considerable extent. Metal smoke pipes should not pass through floors, closets, or other concealed spaces. Such practice often results in fires that are not discovered until they have gained serious headway.

Fireplaces.—Open fireplaces are favored by many because of their cheerful effect. Unprotected fireplaces may involve a considerable danger, however, especially in homes in which there are small children. Besides the danger from flying sparks, clothing may be set afire by too near an approach to the flames, and children at play may fall into the fire. A substantial screen is always necessary before a fireplace which is in use, to avoid danger to the furnishings as well as to persons.

Oil stoves.—Oil stoves for cooking purposes, and sometimes for heating purposes, are found in farm homes. Most of these stoves burn kerosene, but others are constructed for burning gasoline. Oil stoves are dangerous unless used with due care, and those burning gasoline require even greater precaution than those in which kerosene is used.

Lamps.—Oil lamps will probably continue for some time as the most common source of light on the farm, notwithstanding a constant increase in the number of farm homes provided with more modern lighting systems. All oil lamps intended to stand on tables or desks should, for the sake of safety, have a relatively wide base so that they will not easily be tipped over. A metal lamp has an advantage over a glass lamp in that if it should be accidentally tipped over or dropped to the floor, it will not break, and so is not likely to involve flooding the room with burning oil. Gasoline lamps are

occasionally used; they involve added possibility of serious accidents unless handled with special precaution and care.

All oil lamps, as well as oil stoves, should be filled by daylight and, even then, care should be taken that the filling is done well away from a heated stove or a flame of any kind. The term "filling lamps" does not convey the exact meaning. The oil chamber should never be poured so full that there is not ample room for the slight expansion of the oil that results from the heat generated by the lighted wick. If the lamp is so full that the oil extends almost up to the flame the expansion may cause an overflow of burning liquid that endangers the family as well as the house. Lamps should never be placed on rickety boxes or stands but only on solid tables or furniture suitable for the purpose. Furthermore, they should be placed well away from the edge of the supporting surface, so that the danger of their being tipped over and thrown to the floor is remote.

Kerosene to quicken fire.—The use of kerosene to kindle or quicken fires in stoves or furnaces has been the cause of many of the most distressing accidents. If the stove is still warm from the last fire, or if a smoldering fire is in the stove at the time kerosene is poured on, the danger of accident is particularly great. The reports of the State fire marshals abound in concrete and often gruesome warnings against the use of kerosene to quicken fires.

Gasoline.—Although the use of gasoline in lamps or stoves may not be increasing since there is a growing use of electricity, improved kerosene-using devices, and other factors, the use of this powerful oil product for other purposes is becoming more and more common with the increase in the number of automobiles, tractors, and gasoline engines. With proper care, gasoline can be safely handled, but the nature and explosive power of the vapor from this liquid should be kept in mind wherever and whenever it is used. Gasoline in large quantities, outside of special storage areas, should be stored only in underground tanks from which it is pumped as needed. To store gasoline on the premises in other ways involves considerable possibility of accident, and if practiced the dangers should be fully recognized and guarded against by every practicable safety measure. It is unwise and reckless to store gasoline inside any farm buildings. The vapors from this liquid are heavier than air and tend to form first along the floor. A room may contain considerable gasoline vapor before it becomes perceptible to a person in the room; a flame or a spark may cause an explosion before the vapor is noticed. No open flame of any kind should be permitted near by when gasoline is being handled or poured. All portable containers for gasoline should be painted a bright red and should be distinctly labeled "Gasoline."

Acetylene.—Acetylene generated in private plants is used on a considerable number of farms. If the plant and fixtures are properly constructed, installed, and cared for, acetylene is as safe as other recognized means of providing light for the farm and heat for cooking purposes. But this form of gas, which is generated by placing calcium carbide in contact with water, is highly explosive when mixed with a certain quantity of air. The carbide, stored for future use in the generator, must be kept perfectly dry and must be kept in a well-ventilated place. No flame of any kind should be

brought near the generator; should a leak in the system be suspected, it should never be searched for by the use of any form of light with a flame.

Incubators and brooders.—Incubators and brooders carry an element of danger. The fact that they are left burning unattended for long periods makes the danger of accidental fire greater than in the case of oil-burning equipment in the home. The barn is usually one of the worst places to operate these oil-burning devices. If possible, they should be operated in some smaller detached building or shed where, if fire does occur, the loss may be held to a minimum.

Gasoline for cleaning purposes.—The use of gasoline for cleaning purposes involves serious hazards. Many fatal accidents have resulted from this practice. In the open air, the vapor from the gasoline will diffuse rather promptly and lose much of its explosive nature. Indoors the danger is particularly great, because the vapor from open gasoline containers, or from garments saturated with this liquid, is confined and may cause a destructive explosion if a spark or flame of any kind comes in contact with it. The mere rubbing of silk fabric may produce a spark and ignite gasoline vapors. The use of benzene or naphtha for cleaning purposes must be placed in the same hazardous class of practices. Many safe cleaning fluids are available which will neither explode nor burn. The safe practice is to use only such noncombustible cleaning fluids.

Matches.—Matches represent one of the greatest conveniences of civilized man, but their very convenience and the ease with which fire may be produced any time and any where lead to many accidents and destructive fires. Matches are especially dangerous in the hands of children and constitute a serious menace to them as well as to property.

The double-tipped parlor match, which can be recognized by its head of two colors, is considerably safer than the ordinary parlor match, because ignition can take place only when friction strikes the end of the match head. Such a match is rarely ignited by being stepped upon or crushed.

The match that involves the least danger of accidental fire is, however, the well-made safety match that will ignite only when rubbed upon the specially prepared surface of the sides of the box. Such matches never ignite because accidentally stepped upon or crushed. Unless match stems are made of straight and firm wood, there is danger that the stem will break when the match is struck, and that the burning head will set fire to clothing or other material upon which it falls. Particularly on farms, it seems advisable to use only good grades of matches which can be ignited only when struck on the box. Any other kind may conceivably cause a fire by being dropped accidentally in hay and litter and becoming ignited by friction caused in some unexpected way.

Regardless of the kind of matches used, they should be so stored or placed as to be out of reach of small children. Near the stove or other place where matches are regularly used, a metal or glass receptacle for the partially burned match stems should be provided. Throwing supposedly dead matches into the waste-paper basket or the wood box has caused many fires.

Careless smokers.—The careless smoker with his matches is often as great a danger to property as is a child with matches. This danger consists not only in the voluntary lighting of matches and throwing them away before they are completely extinguished but in the accidental dropping of matches in dry hay or litter where they may later ignite by being stepped upon or by friction caused in other ways. The unextinguished cigar butt and particularly the cigarette butt, thrown away while still burning, constitute a serious fire menace. They have been responsible for numerous fires in buildings as well as in forests and fields when grass and leaves are dry. Smoking in or about the barn, or other outbuildings that contain combustible material, should not be tolerated. The result may be a scene such as that shown in Figure 3.



FIGURE 3.—A barn fire spreads rapidly and, unless extinguished before it has a real start, the building is likely to be doomed

Disposal of ashes.—The careless disposal of ashes from stoves or furnaces in active use has caused many farm fires. Even when the ashes recently shaken from the fire box appear to be dead, they may contain live coals which a wind may scatter among dry grass or litter and fan into a flame. Unless metal cans or receptacles are available for the disposal of ashes, care should be taken to see that they are actually dead before they are thrown out and left unguarded. This is particularly important in dry seasons. Safety as well as considerations of neatness suggests that loose ashes should never be dumped near the house.

Accumulation of rubbish.—Needless accumulation of rubbish in attics, cellars, or other storage places add to the fire hazard of the building in which they occur. They not only aid the spread of a fire and hinder its prompt extinction, but they may be directly responsible for starting a fire if oily rags capable of self-ignition are

present among the rubbish, or if matches should be accidentally dropped and later ignited among the trash. The easiest way to dispose of most kinds of rubbish is to pile it at some distance from the house and set fire to the pile. But in so doing due care must be exercised to see that buildings and other property are not endangered. Such fires should never be started on a windy day. Even on a still day the fire should be watched, not only until the blaze ceases but until all smoldering embers are dead.

Christmas trees.—Christmas trees, usually associated only with happiness and good will, have, through thoughtlessness and carelessness, in many instances brought disaster and sorrow. Burning candles on Christmas trees should not be permitted; and even if candles are not used, the decorations should consist of tinsel or other noncombustible material; they should not be made of paper, cotton, or similar flammable material that adds seriously to the fire hazards of the home.

Storage of hay.—The storage of hay or other fodder in barns before it is well dried has caused many barn fires through heating and spontaneous ignition. Clover, alfalfa, and similar kinds of hay with heavy stems that retain considerable moisture after the thinner leaves appear to be dry are considered especially dangerous in this respect. Naturally, this danger is most common when the haying season happens to be rainy and the proper curing and drying of the hay is made difficult, if not impossible. At such a time, the risk of losing the crop or a part of it in the field may have to be weighted against the danger of losing the barn as well as the crop by storing the hay in an uncured and damp condition. The first of these alternatives would normally seem the lesser evil. If the remaining moisture in the hay is not too great, the danger of spontaneous ignition may be lessened by salting the hay during the process of storing. Three to ten pounds of salt per ton of hay, depending on the degree of dampness, will retard fermentation and may prevent spontaneous ignition. But too much reliance should not be placed on this safeguard, and it is not a substitute for proper curing and drying before storage. The spontaneous combustion of hay is discussed in Technical Bulletin 141 of the United States Department of Agriculture.

HOME FIRE-FIGHTING EQUIPMENT

To be of real value, home fire-fighting equipment must be kept in a handy place and kept in condition for instant use. The successful use depends upon early discovery of the fire.

LADDERS

Numerous roof fires are caused by sparks from the top of the chimney or openings in its sides. A ready means of reaching the top of a roof has saved many a building. The results shown in Figure 4 might have been avoided had the dwelling been provided with ladders. The appearance of buildings is sometimes marred by attaching fire ladders, but in many instances the ground ladder can be located inconspicuously and the roof ladder may be merely a narrow board having a few small cleats. In lieu of attached ladders it is well to have two light, strong, portable ladders, one of which has

a large hook for hooking over the ridge pole. Household-ers should be sure ladders are in the best of repair. Fighting fire from ladders and roofs involves enough danger without taking the risk of using defective ladders.

FIRE PAILS AND BARRELS

Many small farm fires are extinguished with the use of a few pails, pans, or dippers of water. The water should be thrown so as to drench the burning material. If directed towards the top of the flame most of the water is likely to be wasted.

Fire pails are usually of wood, fiber, or galvanized steel, and they usually hold about 12 quarts. It is a good plan to paint the outside of the pails red and stencil "For fire only" on them in large black letters. Flat-bottom and cone-bottom pails are in use, but the latter are favored because they do not stand alone and therefore are less



FIGURE 4.—A total loss from chimney sparks on the roof was averted by the timely aid of neighbors with simple home fire-fighting equipment

likely to be used for other purposes. One pail to each 400 or 500 square feet of area served is generally sufficient. The pails should be hung from hooks or brackets or set on shelves 2 to 4 feet from the floor.

The main shortcomings of pail protection are the tendency to use the pails for other purposes, failure to have them always filled, the limiting of the water reserve to the relatively few pails that can be kept on hand, and difficulty or impossibility of reaching fire within flues, partitions, or walls, or on high ceilings, or roofs. Minor disadvantages relate to evaporation, freezing, or stagnation of the water and unsightliness of the pails. Tight, but easily removable covers or lids will lessen evaporation, and 3 to 6 pounds of common salt or calcium chloride dissolved in each pail will usually prevent freezing. A brine of this strength will retard or prevent objectionable odors and the breeding of mosquitoes. If it is not strong enough and if

the water will never be used for other than fire-prevention purposes, a small quantity of copper sulphate, either powdered or in crystals, may be dissolved in the water. A heaping teaspoonful thoroughly dissolved in 50 gallons of water should be sufficient.

Storage of water in casks, barrels, or tanks adds much to the value of pails for fire fighting. Old oil barrels, pork barrels, or cider barrels holding 50 to 60 gallons are suitable. Much that has been stated regarding fire pails applies to other fire reserve containers.

WATER UNDER PRESSURE

Numerous small fires have been extinguished by prompt use of a hand force pump and a piece of hose. A power-driven pump discharging into a good-size hydropneumatic tank from which water is piped to the buildings is, or should be, of still greater value. Roofs, cornices, ceilings, and other spots upon which water could not be thrown with pails can sometimes be wet down sufficiently with a jet from a hose.

The reader is cautioned not to be over sanguine as to the value of small, pressure water systems for fighting fire. To fight a well-ignited fire successfully requires more water and higher pressure than ordinarily is obtained with farm water systems. With 57 pounds pressure at the sill cock, 50 feet of $\frac{3}{4}$ -inch rubber hose, and an ordinary $\frac{1}{8}$ -inch nozzle, the discharge is $7\frac{1}{2}$ gallons per minute—less than three pailfuls. Such a stream directed at a large fire avails little, on account of its dispersion by heat, and it may happen that no water reaches the desired point. Other practical difficulties relate to frozen pipe lines, shortage or defects in the hose, misplaced nozzles, and lack of experience in the skillful use of the equipment when the time comes to fight fire. Although farm water systems are not generally given credit in insurance ratings, they may be of great value if a fire be discovered in its incipient stage, and it undoubtedly is wise, when a pressure system is installed, to provide a few well-placed hose connections. Farmers' Bulletin 1448, Farmstead Water Supply, describes in detail the installation of farm water systems.

CHEMICAL EXTINGUISHERS

Soda-acid type.—Various types of chemical extinguishers are among the special fire-fighting devices that are highly useful on the farm as well as in mercantile or manufacturing establishments. The most common of these types is a $2\frac{1}{2}$ -gallon soda-acid extinguisher. Such extinguishers are usually so made that they can be hung on a wall in any convenient place. Turning the extinguisher upside down from the position in which it hangs causes the soda solution and acid to mix, resulting in the formation of carbon-dioxide gas, the pressure from which expels the solution through the hose. The stream from this extinguisher has force to carry a distance of 30 to 40 feet and the flow continues for about one minute. If directed at the seat of a fire that has not attained serious headway, the stream from such an extinguisher is usually sufficient to put out the fire.

Larger soda-acid extinguishers mounted on wheels are in use in many small towns and villages. They should prove worth-while

equipment on larger farms or estates. These larger extinguishers can be mounted on a rig that forms a convenient trailer to an automobile. In this form they can be conveyed rapidly to assist in extinguishing a fire at a considerable distance.

In winter all soda-acid extinguishers must be placed where the temperature remains above freezing. Salt or other antifreezing ingredients should not be added to the soda-acid type of extinguisher.

Pump-tank type.—A fire extinguisher equivalent in effect to the soda-acid type, but which will not freeze except at very low temperatures, is the pump-tank extinguisher, the usual sizes having capacities of $2\frac{1}{2}$ or 5 gallons. The extinguishing agent is water to which calcium chloride has been added to depress the freezing point. This solution can be expelled by means of the pump to a distance of 30 to 40 feet, which gives these extinguishers about the same range as the soda-acid type.

Carbon tetrachloride hand-pump type.—Another common form of commercial extinguisher is the carbon tetrachloride hand-pump type. The usual sizes are of 1-quart or $1\frac{1}{2}$ -quart capacity. This is not a general-purpose extinguisher, but it is effective if the heavy gas generated by the liquid can form a blanket over the fire that will smother the flames. The liquid is forced out by working the pump with one hand while holding the extinguisher with the other. The stream can be thrown a distance of about 20 feet, and the liquid can be expelled at the rate of a quart in 40 to 50 seconds.

The carbon tetrachloride extinguisher, like the calcium chloride pump-tank extinguisher, has the advantage over the soda-acid type in that it does not freeze under ordinary winter temperatures. In fact it requires a temperature of about -50° F. to cause the special liquid furnished with this extinguisher to congeal. In recharging these extinguishers no liquid other than the special extinguishing liquid furnished by the manufacturer should be used. Ordinary chemical carbon tetrachloride will not serve, as its freezing point has not been depressed and it corrodes the mechanism of the extinguisher.

Under the heat of the fire the carbon tetrachloride mixture vaporizes very rapidly. The vapor formed as soon as the liquid hits the fire is heavy and noncombustible, and in effect smothers the fire by shutting off the oxygen. The fumes generated in fighting fires with carbon tetrachloride extinguishing liquid are intensely irritating and may be dangerous to the operator in confined or poorly ventilated spaces.

Water or the soda-acid mixture has but little effect on oil fires since these liquids are heavier than oil and do not vaporize. The burning oil floats on the surface of the liquid thrown upon it and continues to burn.

Foam type.—Another form of chemical fire-fighting equipment is the foam extinguisher. The most common size is of $2\frac{1}{2}$ -gallon capacity. Turning the extinguisher upside down from the position in which it hangs causes two separately contained chemical solutions to mix. Carbon dioxide gas is formed, the pressure of which expels from the extinguisher a foam of countless small bubbles filled with carbon dioxide gas. This foam is directed to cover the burning surface and smothers the flames. The foam can be thrown a distance of from 20 to 30 feet for about one minute. Like the soda-acid type

of extinguisher, the foam extinguisher must be protected against freezing, but antifreezing ingredients should not be mixed with the solutions to depress their freezing point.

Each type of extinguisher described has its particular field of usefulness. Soda-acid extinguishers are effective on incipient fires in ordinary combustible materials, such as wood, paper, textiles, and rubbish; that is, in cases in which the quenching and cooling effect of quantities of water or of solutions containing large percentages of water is of first importance. They are not effective on fires in flammable liquids, greases, etc., where a blanketing extinguishing effect is essential. Carbon tetrachloride extinguishers are effective on fires in electrical equipment and on small quantities of flammable liquids and greases, where the gas formed by the heating of the extinguishing liquid can be retained as a blanket on the burning material. They are particularly suitable for use on automobiles. They are not effective on fires on which the quenching and cooling effect of water is of first importance. Foam extinguishers are effective not only on incipient fires where the quenching and cooling effect is important, but also on fires in flammable liquids and greases where the blanketing effect is essential.

Sand, soil, and sawdust.—Common sand and soil and even sawdust have been found useful in many instances in extinguishing small fires, such as oil burning on floors. Anyone of these substances tends to smother the fire by shutting off the oxygen. Obviously, to put out a fire with these materials (particularly in the case of sawdust which, if lightly applied, literally adds fuel to the flame) a heavy blanket of the material must be quickly applied. This method of protection against fire should be supplemented with other first-aid extinguishing devices.

Various types of commercial fire extinguishers are on the market, which for one reason or another have not gained the approval of recognized fire-protection agencies. A brief description of a few of these appliances intended for home use, with some indication of the shortcomings of each, will be found in the following paragraphs.

Dry-powder devices.—A so-called dry-powder extinguisher consisting of a tube of paper or metal filled with finely divided inert material, such as brick dust to which has been added some bicarbonate of soda to prevent caking, has been used to some extent in various localities. When thrown upon the fire, this material will under certain conditions smother and extinguish the flame. The quantity of powder in these extinguishers is necessarily small, and in the excitement of discovering a fire, there is considerable danger that little if any of the powder will reach the seat of the fire. Furthermore, unless the limitations of this type of extinguisher are understood, the owner or user will have a false sense of security against fire.

Hand grenades.—Extinguishers described as hand grenades have also been sold. These consist of glass bulbs containing a liquid, generally carbon tetrachloride, or powder. The plan is to throw the closed bulb at the fire causing the glass container to break and release the contents on the fire. These hand grenades, like the dry-powder extinguishers, involve various chances of failure to get the

extinguishing material released at the point intended. There is considerable chance that by inexperienced throwers they will be sent wide of the mark, and there is the further possibility that unless they hit a hard surface, they may fail to break and release the extinguishing material. An automatic feature is provided for one brand of grenade extinguisher by hanging the bulb in a bracket which releases it at a temperature of 130 ° F. or some other designated point. Upon being released from the bracket the glass bulb drops to the floor and breaks, thus pouring out the fire-extinguishing agent. The bulb can also be taken from the bracket and thrown at a fire like the ordinary hand-grenade extinguisher.

Partly because of their low cost, some of these extinguishers have been favored by individuals and groups of individuals. But neither dry-powder (tube) extinguishers nor any of the forms of hand grenade or bulb extinguishers have succeeded in obtaining recognition from the leading fire-protection engineers or organizations of the country.

COMMUNITY FIRE PROTECTION

To bring out more clearly the relation of the third and final fire safeguard, community fire protection, to the other two, let it be assumed that in a certain farm community the suggestions already given have been adopted and followed in a practical way. In other words, let it be assumed that in this community all farmers give reasonable attention to the elimination of fire hazards in the construction and maintenance of their buildings, and exercise reasonable care in the selection and handling of equipment and material used in connection with household fires. Let it be assumed further that each farmhouse in this community is supplied with certain simple fire-fighting equipment which is readily at hand in designated places and with which a fire can be promptly reached and extinguished before it has attained seriously destructive proportions.

In such a farm community the average annual fire loss will be small. Accidental fires will occur only rarely, and of those that do occur a substantial percentage will be extinguished before serious loss takes place. Absolute perfection in individual safeguards has not been assumed, but only such conditions as it would be humanly possible to attain with economic and other factors as they are. It is reasonably certain that even in such a community some fires will occur, and occasionally one of these fires will fail to be discovered until it is beyond control by any ordinary home fire-protection equipment. To the victim of such an occurrence it is slight comfort to know that this seldom happens in his community. What he wants and needs is help in putting out the fire, or at least in keeping it from spreading to other buildings or property.

Hence, even in such a community the need for organized rural fire protection will exist. How much more pronounced, then, is the need for such organized protection in the more typical farm community in which fire prevention and home fire-fighting equipment are given only meager attention?

A rural fire department may not be able in many cases, to save the building in which fire breaks out, particularly if this building happens to be the barn. It will, however, in most cases prevent the

fire from destroying other buildings and property on the place and will thereby substantially lessen the loss that otherwise would occur. Under favorable conditions even the dwelling or other building in which the fire originated may be saved from extensive damage.

The practice of providing organized rural fire protection under some plan or other has been spreading rapidly in recent years. About 15 years ago the few pioneer communities that were trying out a plan of this kind began to attract attention in fire-protection circles. To-day such rural communities are numbered by the hundreds or even by the thousands, if all communities and groups are included which have informal arrangements or some form of organized and specially equipped fire protection service.

Complete information on farm fire departments or service is not available, but the following general statement is based on information supplied largely by State fire marshals or insurance commissioners.

In Maine a substantial part of the rural homes and communities now have fire protection from near-by city or village departments that have been provided with special fire-fighting equipment for rural use.

In many communities, particularly in the State of New York, local mutual fire insurance companies have contributed toward fire equipment for departments in near-by towns in order that the members of these insurance companies may have fire protection.

In eastern Pennsylvania, notable progress has been made in providing fire protection for rural communities from cities, boroughs, and towns, and in a number of counties some of the townships have cooperated in the purchase of fire-fighting equipment. Lancaster County alone has 41 fire companies in unincorporated towns and villages, besides 23 larger organizations in incorporated places. These companies operate a total of 85 fire trucks with pumpers, or chemical outfits, or combinations of both. In other Eastern States, and more especially in Maryland and Rhode Island, considerable progress has been made in safeguarding rural property by local arrangements for fire protection.

In the States of the Middle West, Michigan may be said to be one of the leaders in organized fire protection for farmers. According to the 1928 report by the fire marshal division of the Michigan Department of Insurance, 200 rural fire trucks are in operation in that State. They are usually stationed in cities or villages and are manned by members of paid or voluntary fire companies. Ohio, Indiana, Illinois, Wisconsin, Iowa, and Minnesota all show encouraging development in organized rural fire protection.

Among the far Western States, California stands out as a leader in this movement. During the period of the recent World War a substantial part of the State was organized on a county and community basis into rural fire-protection districts. A total of about 400 local companies are said to have been organized by the end of 1918. Following the close of the war, lack of further progress in this movement, as well as of failure to hold the ground already gained, became evident. Recently, however, there has been a revival of interest in this problem. In 1928, 42 rural fire companies were either organized for the first time or reorganized, and at least

183 such companies, distributed among 20 counties, were in operation during the year.

The California rural fire-protection companies have in most cases differed materially from those in the Eastern or Middle Western States in purpose as well as in organization and equipment. The main function of the California companies has been to fight range, forest, and field fires during the dry summer season that usually prevails in extensive sections of that State, and the fighting of fires in farm buildings has hitherto been an incidental rather than a primary object.

The use of the so-called combine, the machine which reaps and threshes grain in a single operation, has been common for many years in the larger grain sections of the Pacific Coast States. This method of gathering the grain naturally increases the danger of field fires, even aside from any fire hazards connected with the machine itself or the tractor by which it may be drawn. Obviously, leaving the standing grain until it is dry enough to thresh properly means that any fire that gets into such a grain field is likely to cause a serious loss unless promptly discovered and extinguished. The recent extension of the use of the combine in the wheat States of the Middle West and even further east means that here too fire protection for grainfields will be needed to a greater degree than under the older harvesting methods.

RURAL FIRE TRUCKS

Equipment used by fire departments for rural service must necessarily differ from that intended exclusively for urban use. The typical city fire apparatus is not adapted for use on rural roads, or for fire fighting on the farm where, in most cases, only very small quantities of water are available. For country use lighter apparatus is needed; reliance must be placed upon moderate-sized trucks equipped with pumps or chemical tanks, or both, and carrying the necessary hose lines, ladders, hand chemical extinguishers, water buckets, and other equipment.

Suggested standards for such rural fire trucks and equipment have been outlined in a recent report on rural fire departments, by the National Fire Protection Association, with headquarters at 60 Battery-march Street, Boston, Mass. This report was prepared by the committee on farm fire protection, which is working under the auspices of the association, with David J. Price, of the Bureau of Chemistry and Soils, United States Department of Agriculture, as chairman. A copy of the report may be obtained either from the association or from the chairman of the committee on farm fire protection.

The purchase, maintenance, and operation of rural fire equipment is being financed in a number of ways. In perhaps a majority of instances the money has been raised by voluntary subscriptions partly from the farmers concerned and partly from public-spirited business men in the cities and villages at which the apparatus is stationed and whose paid or voluntary fire company provides the necessary fire-fighting force. In other instances the cost is met wholly or in part from public sources such as township, county, or municipal funds, by means of loans or directly by the proceeds from tax levies.

These sources of funds are often supplemented with money raised by local carnivals, fairs, and other social enterprises. A smaller town or village may profit by cooperation with groups of farmers or with townships as much as do the farmers who obtain protection by such cooperation. The fire department of the town or village is likely to be better equipped and therefore more efficient than it would be without such cooperation.

LAWS ENCOURAGING ORGANIZED RURAL FIRE PROTECTION

In a number of States laws have been enacted for the purpose of encouraging and promoting organized rural fire protection. These laws permit townships, or districts organized specifically for fire protection, to appropriate money, levy taxes, and in some instances to issue bonds, either to purchase fire-protection equipment and provide for its maintenance and use, or to contract for such service from cities, towns, or villages. The States having such laws include California, Illinois, Indiana, Iowa, Michigan, Minnesota, New York, Ohio, Oregon, Pennsylvania, and Wisconsin.

On the basis of the nature of the legislation on this subject these 11 States may be divided into two groups. The laws of the larger of these groups, which includes 7 States, provide for an enlargement of the powers of township governments to include the right to provide fire protection under stipulated conditions. The laws of the other group, which include California, Illinois, New York, and Oregon, authorize the organization of special rural fire-protection districts without reference to township borders.

The laws in the States of the first group, which have what may be called the township plan, differ from one another in various respects. Although they all authorize the expenditures of township funds for the purpose of fire protection, in some cases this can be done only as a result of a vote of the township electors, and in other cases the power is vested more directly in the township officers. The amount that may be expended for this purpose in any one year is usually limited, and the choice of organizing and equipping their own fire departments, or of contributing to the equipment and support of an existing city, town, or village department which agrees to provide rural fire-protection service, is usually left with the township. The limit to expenditures for new equipment in any one year is usually \$5,000 or \$6,000, and the amount that may be expended for upkeep and use varies, in so far as it is stipulated, from \$1,000 to \$2,500. The former amount covers the average cost of a well-constructed and equipped rural fire truck. Some of these laws provide not only that townships may cooperate with incorporated places for this purpose, but also that two or more townships may cooperate with one another in establishing, equipping, and maintaining fire-protection organizations.

The States which authorize the formation of rural fire-protection districts naturally have somewhat more elaborate legal provisions since in these cases it was necessary to set up a procedure for the incorporation and organization of these districts as well as to provide for their management. In the four States with laws of this kind, fire-protection districts may come into existence only as the result of a vote or a petition representing the major part either of

the voters or of the property affected by the proposed action. Under the laws of California and New York the actual incorporating of such districts is done by the county supervisors, whereas in Illinois and Oregon the county judge of the county in which all or a major part of the proposed district is located takes charge of the election and appoints a board of trustees to manage the fire-protection district.

In most of the 11 States the laws here considered have been either enacted or materially amended during the last few years. Their final value or significance can not therefore be determined at this time. It seems highly desirable, however, that organized rural fire protection should be encouraged and promoted by giving townships or other rural units an opportunity to provide for such protection wholly or in part through existing governmental machinery.

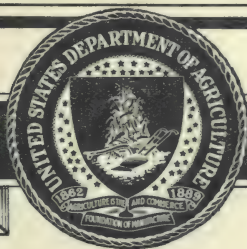
CONCLUSIONS

No practical application of fire safeguards either by the individual or by the community, or by both combined, will entirely eliminate the possibility of loss by fire. But the probability of such loss occurring to a given farm home can be greatly lessened, and the aggregate of the annual losses for any larger group or for all American farm homes can be greatly reduced from its present total. This should mean correspondingly reduced cost of insurance protection against such few losses as may nevertheless occur and correspondingly greater personal safety to the farmer and his family.

The burning of a farm building worth \$2,400 means to an owner who has no insurance that he himself loses that amount. To the wiser owner of such a building, who has his property insured to the usual extent of about three-fourths of its value, such an occurrence means that the insurance company loses about \$1,800 and he himself the remaining \$600. In addition, as in the case of the uninsured owner, he suffers the inconvenience or loss of being without the building until it can be replaced. Regardless of whether the property was insured the Nation is poorer by the \$2,400 represented by the building burned unless a part of the insurance was carried in a foreign insurance company. In the latter case it would still be true that mankind is poorer by the full amount of the loss.

Insurance is indispensable to the individual who wishes to play safe. But insurance does not create wealth to replace that which is lost. It merely distributes the loss, or a greater part of it, over a larger or smaller group of individuals. It is no real substitute for fire prevention and fire protection either from the point of view of the honest insured or from that of civilized society. This general truth applies to farmers quite as much as to any other economic group. Reasonable fire safeguards for the farm in the form of proper fire prevention measures, simple but effective home fire-fighting equipment, and organized rural fire protection, are essential to rural progress and safety.

Local **BIRD REFUGES**



Farmers' Bulletin

No. 1644

BIRDS appeal strongly to the interests and affections of mankind. Not only do they charm by their graceful forms, harmonious colors, sprightly actions, and usually pleasing notes, but they have an even more important claim upon our esteem because of their great economic value.

Birds feed upon practically all insect pests. They are voracious, are able to move freely from place to place, and exert a steady influence in keeping down the swelling tide of insect life.

For economic as well as for esthetic reasons, therefore, an effort should be made to attract and protect birds and to increase their numbers. Where proper measures of this kind have been taken an increase of several fold in the bird population has resulted, with decreased losses from depredations of injurious insects.

This bulletin deals with the establishment of local refuges as a means of attracting birds and is adapted for use throughout the United States. It supersedes Farmers' Bulletin 1239, Community Bird Refuges.

Washington, D. C.

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LOCAL BIRD REFUGES

By W. L. McATEE, *technical adviser and research specialist, Office of the Chief,
Bureau of Biological Survey*

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INTRODUCTION

BIRD CONSERVATION in the United States is a well-established policy that has been written into one of the best codes of State and Federal protective laws in the world. Originally, the basis of much of this legislation was the demonstrated practical value of birds as natural agencies in the control of injurious insects, but with the passage of time widespread appreciation of the birds' esthetic worth has developed into an effective country-wide bird-protective sentiment. Notwithstanding this fine public spirit for Nation-wide conservation, it is important that the human friends of the birds give practical attention to special local needs for their welfare.

One of the most effective ways of providing for birds is to develop various types of local refuges. In creating a useful bird refuge, the first step is to insure adequate protection against important bird enemies; the second, to see that plenty of nesting sites suited to the needs of various birds are available; and the third, to improve food and water supplies, where necessary.¹ Instructions as to the use of nest boxes are contained in Farmers' Bulletin 1456, Homes for Birds, which is adapted to the whole country. Information on fruits attractive to birds in various regions of the United States (fig. 1) is given in mimeographed leaflets obtainable from the Bureau of Biological Survey.¹

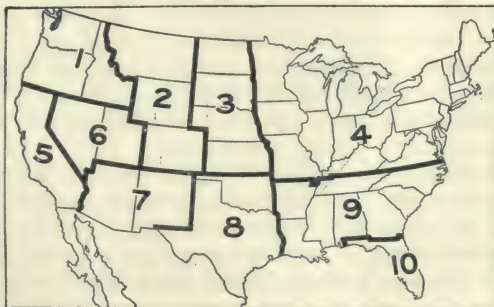


FIGURE 1.—For each of the regions shown on this map, fruits attractive to birds are listed in mimeographed leaflets obtainable from the Bureau of Biological Survey (see footnote 1).

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¹Addresses of dealers in devices for attracting birds and a list of publications on the subject available from other sources are obtainable on application to the Bureau of Biological Survey, Department of Agriculture, Washington, D. C., as are also the following mimeographed leaflets on fruits attractive to birds in the various regions of the United States, as shown on the map (fig. 1): For region 1, Leaflet BS-41, Northwestern States; region 2, BS-42, Rocky Mountain States; region 3, BS-43, Northern Plains States; region 4, BS-44, Northeastern States; region 5, BS-45, California; region 6, BS-46, Great Basin States; region 7, BS-47, Southwestern States; region 8, BS-48, Southern Plains States; region 9, BS-49, Southeastern States; region 10, BS-50, Florida.

BIRD REFUGES ON FARMS

Farmers, more than any other element of the population, will be interested in the establishment and maintenance of effective bird refuges, for the welfare of crops and the commercial success of the farm are intimately related to the numbers and kinds of birds present and to their economic tendencies. In the case of certain species that are more or less injurious, control measures are sometimes necessary, but the great majority of birds vary from slightly to almost exclusively beneficial in their relations to the farm. The useful species merit the fullest protection and should be encouraged in every possible way.

The value of birds lies chiefly in their destruction of injurious insects. Leading an active life, they require much food and are the most ravenous enemies of pests of this kind. The various groups of birds differ so much in habits that they feed upon practically all groups of insects; hardly an agricultural pest escapes their attacks. The alfalfa weevil has 50 different bird enemies; the army worm, 43; billbugs, 110; the cotton-boll weevil, 66; the brown-tail moth, 31; chestnut weevils, 85; the chinch bug, 29; clover-root borers, 94; the clover weevil, 48; the codling moth, 36; the cotton worm, 41; cutworms, 98; the forest tent caterpillar, 32; the gypsy moth, 46; horseflies, 49; leaf hoppers, 175; the orchard tent caterpillar, 43; the potato beetle, 34; the rice weevil, 22; the 12-spotted cucumber beetle, 42; white grubs, 95; and wireworms, 205.

In feeding on insect pests not only do birds take a great variety but they frequently destroy very large numbers. Often more than a hundred individuals are devoured at a meal, and in the case of small insects sometimes several thousand. With such appetites it is not surprising that occasionally birds entirely destroy certain insects locally. A number of cases are known in which trees, garden crops, and even farm fields have been entirely freed of insect pests by birds. On a 200-acre farm in North Carolina it was found that birds were destroying a million green bugs, or wheat aphids, daily.

On the average there are in the United States only about two birds to the acre, but where they are protected and encouraged it has been demonstrated that a great increase over the normal bird population can be brought about. No fewer than 59 pairs to the acre is the figure reached in the most successful of these attempts reported. Bird counts as noted in many instances give an average of a pair of birds to the acre in the breeding season. Birds that pass through the United States to breed in the northerly parts of North America equal, if they do not surpass, in number the population of breeding birds.

The arid section of the United States has fewer birds than the humid, and if an estimate of one pair of birds to the acre is made for the humid regions, it will be safe to use half that number, or one bird to the acre, for the arid region. The totals reached from these calculations are more than 1,161,000,000 breeding birds for the arid, and more than 1,483,000,000 for the humid States.

For the purpose of computing their value in destroying pests, the breeding birds may be reckoned as preying upon them during 6 months of the year. The migrants that pass entirely beyond the borders of the United States may be estimated to spend a month on each northward and southward passage. Their repressive effect

on insect and other pests is exerted therefore over a period one-third as long as that of the breeding birds.

By estimating the value of each breeding bird in the destruction of insects at only 10 cents a season (a purely nominal figure) and the value of the strictly migratory birds at one-third of that figure (3.3 cents), corresponding to the relative time they spend within the United States, and by using the numbers of birds to the acre noted before, a valuation of the services of birds is reached of nearly \$200,000,000 for the humid region and more than \$150,000,000 for the arid region. The total, \$350,000,000, is about a fourth of a recent estimate (\$1,590,040,500) of the total damage wrought by insects.

A particular farm may not have so large a bird population as it should, and therefore may not be deriving the benefit that is its due. The most effective means of increasing the number of birds is protection, and protection in its best sense is afforded by the establishment of bird refuges.

Bird refuges on farms have been most successful when established and maintained on a cooperative plan between the landowner or landowners and a State game commission, an Audubon society, a bird club, or a school. The owner agrees to the use of the land and acts as warden, and the other party to the contract furnishes and places posters, bird houses, and feeding stations, or even stocks the refuge, as in the case of reservations for game birds. The beneficial effect that the establishment of a bird refuge has upon trespass problems is a great advantage to the farmer. A State law authorizing game wardens to proceed against trespassers on bird reservations greatly increases the effectiveness of private and cooperative bird refuges.

The cooperative bird preserve has been tried in many States as a means of establishing colonies of game birds, such as pheasants, and the plan has invariably proved popular and successful. As a method of protecting insectivorous birds it has been put into practice by schools, bird clubs, and Audubon societies in New Hampshire, Connecticut, Illinois, and Minnesota, at least, and has been found satisfactory and effective.

WOOD LOTS

As applied to wood lots, bird protection and attraction methods must be simplified. It is not feasible, as a rule, to adopt special protective measures, but vagrant cats and occasionally a sharp-shinned hawk, Cooper's hawk, or red squirrel can be eliminated from the farm.

If a wood lot contains no small streams, it will probably be impracticable in most cases to furnish water. If there is a water supply not far away, some birds no doubt will nest in the wood lot, but if there is none within easy flying range, the other woodland attractions will go for naught.

The provision of nest boxes is an obligation nowadays upon all who would help birds. No longer is there the profusion of decaying or dead trees containing cavities that once formed the natural homes of a whole series of valuable birds. Unless nest boxes are provided for these species, all but the most expert drillers among the woodpeckers, and the few birds that fall heir to their abandoned nest

cavities, will become greatly reduced in numbers. These hole-inhabiting birds, as the woodpeckers, crested flycatcher, tree swallow, house wren, nuthatches, titmice, chickadee, and bluebird, are among the most valuable bird friends of the forest, and action should be taken in every wood lot to furnish them places to rear their young.

Besides protection, water, and nest boxes, the birds' food supply should receive some attention. It is easy, for instance, in clearing woodlands to spare, here and there, a Juneberry, raspberry, blackberry, elderberry, or mulberry bush. The presence of their favorite wild fruits will induce more birds to nest in the wood lot and will help them with their food problems. If wild berries are not already present, it will be well to plant some of the most favored kinds about the woodland margins. A list of these fruits will be found



FIGURE 2.—Birds attracted by food in winter.

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in table 1, page 8, and the seasons when they are in bearing in the different sections of the country are given in the mimeographed leaflets mentioned on page 1.

Winter is the time of the birds' greatest need for artificial provision of food (fig. 2). The foods commonly used for winter feeding include suet or other fat, pork rinds, bones with shreds of meat, various seeds, and the like. The methods of making these supplies available to birds are as varied as the dietary itself.

Feeding places for game birds and sparrows may be provided by erecting low hutches or making wigwamlike shocks of corn or grain sheaves under which food may be scattered. The opening should be to the south. These shelters should be inspected about once a week to see that they are not covered or blocked with snow, and to renew the food supply. If predatory animals are attracted to such spots, discontinue feeding there, scatter the food in a different place each time, and take steps to control the predators.

In thinning trees it would be well, also, to allow for entertaining some of the seed-eating birds. Alders and birches bear in their

numerous cones a supply of seeds eagerly sought by redpolls, siskins, and goldfinches in winter. The winged fruits of ashes and boxelders are opened and the seeds eaten by pine and evening grosbeaks. Larches, pines, and other conifers attract crossbills, as well as some of the species just mentioned.

A fundamental of forest protection is prevention of sweeping fires, which not only directly kill trees, especially those of the younger generation, but consume the humus so necessary to healthy forest growth and to water conservation. Fire also damages trees not killed, by rendering them more subject to attacks of insects and to decay. Prevention of fires is for the good of birds as well as of trees. The measures that are recommended to minimize damage by fire, such as cleaning out old roads and trails as fire barriers and breaking up large woodlands into blocks by open fire lanes, also encourage the presence of birds. Birds are much more numerous around the margins and in openings of woodlands than in extensive dense forests, and in mixed plantings more than in pure stands.

Another good wood-lot policy that benefits the birds is excluding grazing animals, for the undergrowth is of importance in furnishing nesting sites and food for the birds and, together with the leaf mold, in maintaining a sufficient degree of humidity. Although it is contrary to general practice, foresters advise against grazing in wood lots. A closely pastured wood lot is recognizable at a glance; the ground is bare, puddled, and hard, and the undergrowth and limbs of the trees as high as the cattle can conveniently reach have been destroyed. The old trees are injured (stag-headed) by the compacting of the soil around their roots and by destruction of the humus layer, and reproduction is entirely prevented. Grazing and the continuous forest reproduction that is so necessary for profitable wood lots are incompatible.

Gradual rather than widespread cutting of wood lots is recommended, as it interferes less with general conditions favorable to trees and always leaves some of the older seed-bearing trees to provide for reproduction. This policy also is favorable to birds, for it permits most of them to resort to the same area year after year instead of seeking new homes, and in general involves the least change in the essential conditions of the environment. Indeed, practically everything that is good for maintaining the wood lot is good for birds.

ROADSIDES

Making bird refuges on farms, although of most direct interest to the farmer, is by no means the only activity along this line helpful to agriculture. Attracting birds to roadsides and rights-of-way, in particular, is of almost equal importance and furnishes a leading reason for urging a treatment of these public and semipublic travel ways that will not only increase their bird population but make them more sightly. Both features will increase the value of the adjacent farms.

In many parts of the United States roadsides are shorn of their vegetation at least once a year, either as a result of local sentiment or of legal requirement. Consequently, many country roads are very uninviting in summer. Hot, and gray with dust, the highway stretches away before the traveler, often without a single tree to

break the monotony of the view or afford relief from the rays of the sun. This baldness is brought about chiefly by two causes: (1) Fear that the roadside will unduly increase weeds and insect and rodent pests; and (2) lack of public spirit.

Fortunately, there are also in this country examples of well-kept parkways and boulevards bordering cultivated lands. Their ample parking is grown to grass and embellished with herbaceous flowering plants, shrubs, and trees. Yet the farm lands they border are neither overwhelmed by weeds nor devastated by insects and rodents.

The possibility of roadsides propagating vast numbers of noxious weeds may be viewed in more than one light. For instance, the mowing of waysides for long series of years has not done away with the need of cultivating adjacent crops; indeed it cannot, for cultivation is necessary for other reasons than the destruction of weeds, as the loosening and aeration of the soil, and water conservation. Furthermore, the degree of cultivation customarily given crops is sufficient to control all the weeds the land will grow, and this number is generally present, despite the razing of roadside growths. On the other hand, the lack of verdure and shade and the general dreariness of roadsides make the adoption of a different treatment of these most extensive public parkings very desirable. Placing vines upon fences and planting numerous shrubs and shade trees along the way will not only render the roads more attractive but will tend to keep down the dust.²

In the case of paved highways it has been demonstrated also that roadside trees prolong the life of the pavement by protecting it from extremes of temperature. This is particularly true of the heat of summer, which, depending on the nature of the pavement, may either expand it, causing the surface to be thrown into waves, or dry it out, forming cracks.

Another practical end of planting may be served by using nut-bearing trees, which could be made a definite source of revenue to the community. In choosing plants for roadsides, as elsewhere, be sure to omit the common barberry, which serves as an alternate host for wheat rust, and buckthorn, carrier of the crown rust of oats; gooseberries and currants, which have a similar relation to the white-pine blister rust; and the wild black cherry, which is a favorable nursery for tent caterpillars.

There can be no doubt that suppression of roadside vegetation is a potent factor in restricting the numbers of birds, and the ever-increasing tendency to allow fence rows the minimum of space has the same effect. Farmers may gain a planting row about every field by the destruction of vegetation along fences, but they lose the services of the birds, their best allies in fighting insects.

Shrubby fence rows are among the best harbors and nesting places of small birds, and it is certain that encouraging an abundance of birds to live on farms by such plantings is a profitable policy. More should be done to beautify roadsides and fence rows, not only as a

² In this connection Farmers' Bulletin 1482, *Trees for Roadside Planting*, will be helpful.

measure to contribute to the comfort and pleasure of man, but also substantially to increase a great economic asset—the bird population of the country.

The windbreaks so useful on farms in prairie regions are in effect but shrubby fence rows magnified. Their utility in protecting crops from winds always is supplemented by that of furnishing nesting sites for birds, and a food-supplying function also may easily be added, for Russian-olive, buffaloberry, and hackberry, all good bird foods, are highly recommended as windbreaks.

RIGHTS-OF-WAY

A number of railroad companies have already made considerable effort to beautify their rights-of-way and station grounds. In some places the roads are paralleled for many miles by hedges, and the land on either side of the tracks is covered by beautiful turf. Hedges, shrubbery, and flower beds are common about the stations. If this planting could be directed in part, at least, toward attracting birds, it would be very effective and great good would be done. If the clumps of shrubs were formed of kinds furnishing the birds food (see table 1) and more of them were placed along the rights-of-way, the hedges allowed to bear fruit, and the fence poles or possibly even some of the telegraph poles furnished with bird houses, thousands of birds could live where very few do now.

The suggestions made are by no means without practical value to the right-of-way itself. For instance, supplying bird boxes is the best method of preventing damage to poles by woodpeckers, which come anyway under present conditions and make their own homes. Hedges or fences densely covered with vines would decrease, if they would not entirely obviate, expenditures for the movable snow fences now extensively used.

The project of increasing the number of birds along rights-of-way should interest the agricultural-development bureaus of railroads. The small birds that are most easily encouraged when shrubbery, nest boxes, and water supply are provided are chiefly beneficial, and increasing their numbers would result in great destruction of insects on adjacent farms, a very practical bit of agricultural improvement.

COMMUNITY PARKINGS

The attractiveness of community parkings, including those of cities and villages as well as of rural areas, may well be enhanced by the presence of an abundance of birds. This can be effected without in any way detracting from the utility of these reservations for their leading purposes. Making community parkings safe for birds is the first step: they must actually be havens of refuge. In this connection may be cited the admirable law of the State of Oregon that provides that all incorporated towns and cities and all public parks and school grounds in the State shall be, without additional local or general legislation, bird and game sanctuaries.

TABLE 1.—Groups of fleshy fruits¹ most attractive to birds throughout the United States

Name of fruit ²		Birds known to eat the fruit	
Common	Generic	Number ³	Desirable kinds most fond of the fruit ⁴
Juniper; redcedar ⁵	<i>Juniperus</i>	54	Ruffed and sharp-tailed grouse, bob white, eastern flicker, mockingbird, robin, eastern bluebird, cedar waxwing, myrtle warbler, evening and pine grosbeaks, purple finch.
Greenbrier.....	<i>Smilax</i>	44	Ruffed and sharp-tailed grouse, bobwhite, wild turkey, eastern flicker, red-bellied woodpecker, mockingbird, catbird, brown thrasher, robin, hermit thrush, cardinal.
Bayberry.....	<i>Myrica</i>	86	Ruffed grouse, bobwhite, eastern flicker, red-bellied and downy woodpeckers, eastern phoebe, tree swallow, black-capped chickadee, Carolina wren, catbird, brown thrasher, hermit thrush, eastern bluebird, white-eyed vireo, myrtle warbler, meadowlark, eastern towhee.
Hackberry.....	<i>Celtis</i>	48	Gambel's and scaled quails, eastern flicker, yellow-bellied sapsucker, mockingbird, brown thrasher, robin, hermit thrush, eastern bluebird, cedar waxwing, cardinal.
Mulberry ⁶	<i>Morus</i>	44	Yellow-billed cuckoo, red-bellied, red-headed, and downy woodpeckers, eastern kingbird, mockingbird, catbird, robin, wood thrush, cedar waxwing, red-eyed vireo, yellow warbler, orchard and Baltimore orioles, scarlet tanager, cardinal, purple finch.
Pokeberry.....	<i>Phytolacca</i>	53	Bobwhite, mourning dove, eastern flicker, eastern kingbird, mockingbird, catbird, robin, hermit, olive-backed, and gray-cheeked thrushes, eastern bluebird, cardinal, eastern towhee.
Sassafras.....	<i>Sassafras</i>	19	Bobwhite, eastern kingbird, catbird, robin, veery, red-eyed vireo.
Spicebush.....	<i>Benzoin</i>	17	Bobwhite, eastern kingbird, catbird, wood thrush, veery, red-eyed vireo.
Apple.....	<i>Malus</i>	44	Ruffed grouse, bobwhite, ring-necked pheasant, eastern flicker, red-headed and Lewis's woodpeckers, mockingbird, robin, cedar waxwing, purple finch, pine grosbeak, red crossbill.
Chokeberry.....	<i>Aronia</i>	19	Ruffed and sharp-tailed grouse, bobwhite, brown thrasher, meadowlark.
Mountain-ash.....	<i>Sorbus</i>	14	Ruffed and sharp-tailed grouse, red-headed woodpecker, catbird, brown thrasher, robin, Bohemian and cedar waxwings, Baltimore oriole, evening and pine grosbeaks.
Juneberry.....	<i>Amelanchier</i>	42	Eastern flicker, red-headed woodpecker, catbird, robin, hermit thrush, veery, cedar waxwing, Baltimore oriole.
Hawthorn.....	<i>Crataegus</i>	39	Ruffed grouse, bobwhite, robin, purple finch, pine grosbeak.
Strawberry.....	<i>Fragaria</i>	53	Ruffed grouse, catbird, brown thrasher, robin, wood thrush, cedar waxwing, eastern towhee.
Raspberry, blackberry.	<i>Rubus</i>	149	Ruffed and sharp-tailed grouse, bobwhite, eastern flicker, red-headed woodpecker, eastern kingbird, tufted titmouse, wren tit, mockingbird, catbird, brown thrasher, robin, wood and olive-backed thrushes, eastern bluebird, cedar waxwing, red-eyed vireo, orchard and Baltimore orioles, cardinal, rose-breasted, black-headed, and pine grosbeaks, eastern, spotted, and brown towhees, white-throated, fox, and song sparrows.
Rose.....	<i>Rosa</i>	42	Ruffed and sharp-tailed grouse, greater prairie chicken, bobwhite.

¹ Barberries (*Berberis*), buckthorns (*Rhamnus*), and currants (*Ribes*) are omitted because they serve as alternate hosts of rusts, attacking wheat, oats, and white pine, respectively. Yews (*Taxus*), wild cherries (*Prunus*), and nightshades (*Solanum*) also are omitted as being dangerous stock-poisoning plants.

² Only those listed that have been found in the stomachs of 10 or more species of birds.

³ Based on records of stomach analyses made by the Bureau of Biological Survey.

⁴ Based on both stomach analyses and field observations.

⁵ Carries apple rust; should not be planted near valuable orchards.

⁶ Most birds eat mulberries. A list of 26 species observed to do so in Washington, D. C., was published in the report for 1890 (p. 285) of the Ornithologist and Mammalogist to the Secretary of Agriculture. A good many of the species are additional to those in the stomachs of which mulberries have been found.

TABLE 1.—Groups of fleshy fruits most attractive to birds throughout the United States—Continued

Name of fruit		Birds known to eat the fruit	
Common	Generic	Number	Desirable kinds most fond of the fruit
Crowberry.....	<i>Empetrum</i>	42	Ruffed grouse, pine grosbeak, tree sparrow, snow bunting.
Sumac ⁷	<i>Rhus</i>	98	Ruffed grouse, bobwhite, valley quail, wild turkey, eastern and western flickers, red-headed and downy woodpeckers, phoebe, black-capped and Carolina chickadees, wren tit, Carolina wren, mockingbird, catbird, brown and California thrashers, robin, hermit and olive-backed thrushes, eastern bluebird, white-eyed vireo, Audubon's warbler, goldfinch, eastern towhee, golden-crowned sparrow.
Peppertree.....	<i>Schinus</i>	11	Robin, varied and hermit thrushes, cedar waxwing, phainopepla.
Holly.....	<i>Ilex</i>	49	Ruffed grouse, bobwhite, valley quail, eastern flicker, mockingbird, catbird, brown thrasher, robin, hermit thrush, eastern bluebird, cedar waxwing.
Supplejack.....	<i>Berchemia</i>	16	Mockingbird, robin.
Grape.....	<i>Vitis</i>	89	Ruffed grouse, bobwhite, wild turkey, eastern and red-shafted flickers, red-bellied woodpecker, eastern kingbird, mockingbird, catbird, brown thrasher, robin, wood thrush, veery, eastern and western bluebirds, cedar waxwing, cardinal.
Virginia creeper.....	<i>Parthenocissus</i> ..	39	Ruffed grouse, bobwhite, eastern flicker, red-bellied and red-headed woodpeckers, tufted titmouse, mockingbird, brown thrasher, robin, hermit, olive-backed, and gray-cheeked thrushes, eastern bluebird, red-eyed vireo, scarlet tanager, evening grosbeak, purple finch.
Buffaloberry.....	<i>Shepherdia</i>	19	Ruffed and sharp-tailed grouse, mockingbird, hermit thrush, pine grosbeak.
Wild sarsaparilla.....	<i>Aralia</i>	18	Ruffed grouse, bobwhite, robin.
Dogwood.....	<i>Cornus</i>	98	Ruffed and sharp-tailed grouse, bobwhite, eastern and western flickers, downy woodpecker, eastern kingbird, catbird, brown thrasher, robin, hermit, wood, olive-backed, and gray-cheeked thrushes, veery, eastern bluebird, cedar waxwing, red-eyed and warbling vireos, cardinal, evening and pine grosbeaks, purple finch, white-throated and song sparrows.
Sour gum, tupelo.....	<i>Nyssa</i>	40	Ruffed grouse, bobwhite, wild turkey, eastern flicker, brown thrasher, robin, olive-backed and gray-cheeked thrushes, eastern bluebird, cedar waxwing, purple finch.
Wintergreen.....	<i>Gaultheria</i>	11	Ruffed and sharp-tailed grouse, wren tit.
Bearberry, manzanita.....	<i>Arctostaphylos</i>	34	Dusky and ruffed grouse, valley and mountain quails, band-tailed pigeon, wren tit, fox sparrow.
Huckleberry.....	<i>Gaylussacia</i>	48	Ruffed grouse, robin, pine grosbeak, eastern towhee.
Blueberry.....	<i>Vaccinium</i>	93	Ruffed grouse, greater prairie chicken, sharp-tailed grouse, bobwhite, valley quail, wild turkey, eastern kingbird, black-capped chickadee, tufted titmouse, catbird, brown thrasher, robin, hermit thrush, eastern bluebird, cedar waxwing, orchard oriole, cardinal, pine grosbeak, eastern towhee, tree sparrow.
Beautyberry.....	<i>Callicarpa</i>	11	Bobwhite, mockingbird, brown thrasher.
Partridgeberry.....	<i>Mitchella</i>	10	Ruffed grouse, bobwhite.
Honeysuckle.....	<i>Lonicera</i>	20	Bobwhite, catbird, brown thrasher, robin, hermit and olive-backed thrushes, pine grosbeak, white-throated sparrow.
Snowberry, coral-berry.....	<i>Symphoricarpos</i>	36	Ruffed and sharp-tailed grouse, bobwhite, valley quail, varied thrush, evening and pine grosbeaks.
Blackhaw, cranberry-bush.....	<i>Viburnum</i>	35	Ruffed and sharp-tailed grouse, yellow-billed cuckoo, eastern flicker, catbird, brown thrasher, robin, eastern bluebird, cedar waxwing, purple finch, pine and rose-breasted grosbeaks, common redpoll.
Elderberry.....	<i>Sambucus</i>	120	Ruffed grouse, valley quail, eastern flicker, red-headed woodpecker, eastern and Arkansas kingbirds, black phoebe, wren tit, mockingbird, catbird, brown and California thrashers, robin, olive-backed thrush, eastern and western bluebirds, phainopepla, red-eyed vireo, rose-breasted and black-headed grosbeaks, brown towhee, white-crowned sparrow.

⁷ Only nonpoisonous species are considered.

MUNICIPAL PARKS AND PICNIC AND FAIR GROUNDS

Picnic grounds, fair grounds, and parks may be improved as places of public gatherings, recreation, and education by increasing their bird population. Moreover, the alterations that improve a park as a bird haven may, and should, themselves be made to add to its attractiveness. For instance, water is used to enhance the beauty of most parks, and a water supply is one of the most potent attractions for birds (fig. 3). Bird baths or bird fountains may take the form of small displays of water, which may be added to many parks without being obtrusive or in conflict with the general design.

An artistic martin house, well placed in one of the small open lawns that most large parks contain (fig. 4), would not only increase the beauty and interest of the park, but would add to its dignity by suggesting a specific usefulness for the space. As for nest boxes



FIGURE 3.—Cedar waxwings attracted to bird fountain.

B806M

for other birds, they may be so inconspicuously placed that the chief evidence of their presence would be the increased number of birds and the lessened injury to vegetation by insect pests. The perfection of specimen trees in parks and the work of the tree surgeon on imperfect trees make it necessary to supply nest boxes if the hole-nesting birds are to have any chance of inhabiting parks.

Feeding stations for birds are made in a number of slightly designs, and the principles upon which they are built allow of their being extensively varied or incorporated into other park structures. The greatest usefulness of feeding stations in parks, aside from the preservation of birds, is in rendering such places more attractive to the public in winter. The feeding of birds is carried on with most obvious results during the colder months, and adding this feature to parks appeals strongly to thousands of lovers of nature.

By means of feeding stations it is possible to attract to convenient observation points several species of the most interesting and valuable birds. Such stations are particularly pleasing to children. As evidence of the value of the method, the following statement of experience by the superintendent of parks, Minneapolis, Minn., is presented:

For the past 5 or 6 years we have maintained a number of feeding stations in various parts of our park system, with very satisfactory results. I give you a list of the birds which stay with us over winter. The permanent winter birds found in the vicinity of our parks are the chickadee, blue jay, white-breasted nuthatch, downy and hairy woodpeckers, and screech owl; winter visitors, the redpoll, tree sparrow, and junco; irregular winter visitors, the evening grosbeak, Bohemian waxwing, and snow bunting. It is safe to say that a large number of these species are staying in the parks on account of the food supplied them. The feeding of the wild birds in the parks is a great success and will be continued.



FIGURE 4.—Martin house and bird bath in parklike surroundings.

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Supplying water, nest boxes, and winter food goes far toward making a bird haven, but it is important also to supplement the summer food. This can best be done by planting fruit-bearing shrubs and trees. Shrubs and trees are essential elements of park composition, but according to the judgment of bird lovers better choice is distinctly possible than that often made.

The guiding principle in park planning should be beauty, but it should not be a temporary or one-season beauty. Hence it follows that shrubs and trees that produce colored fruits and retain them for long periods are preferable to plants whose chief decorative contribution is a short burst of bloom. Such shrubs are handsomer at all times after flowering and are particularly valuable in winter when every bit of color in the landscape is precious. They are valuable, moreover, in supplying bird food. The kinds preferred by birds are shown in table 1, and the species most suitable for various

sections of the country are listed in the mimeographed leaflets mentioned on page 1. (See fig. 1 and footnote 1.)

A few further suggestions as to the use of fruit-producing plants are not out of place. The ideal American park is natural woodland modified and embellished, or a planting that follows natural lines. Informal treatment is almost universally preferred to formal. From the standpoint of bird attraction this is fortunate, since clipping shrubs either prevents or reduces the production of fruit and causes the plants to form such solid and dense surfaces that they are uninviting to birds. It may further be said in favor of untrimmed shrubbery that the normal form and beauty of the plants, together with the resultant play of light and motion, are preserved. With this treatment a park has naturalness and life; under formal treatment the suggestions are those of restraint and immobility.

SCHOOL AND COLLEGE GROUNDS

Too often public-school grounds are bare and uninviting. How much better it is to clothe, shade, and adorn them with green! Flowers and trees will make the students more content with their surroundings, inspire them to better work, and enshrine the school grounds in pleasant memories delightful to recall in later years. Almost everything done to beautify the grounds will help to attract birds. Trees and shrubs cradle their young and supply much of their food.

The birds, the trees, and the flowers in themselves are a valuable educational resource, and are necessities for the proper conduct of classes in nature study, now deservedly so popular. Building and placing bird houses could well be part of such a course, and the winter feeding of the birds would attract living objects of interest during the dormant season of the trees and shrubs. All children like birds and will protect and encourage them if only their early steps are guided right.

The college campus, like the park, has suffered from formal landscape gardening. Wall-like hedges, closely cropped circles, triangles of shrubs, and mathematically designed edgings, beds, and gardens have gone far toward robbing school grounds of merit in the eyes of man, and have almost spoiled them for birds.

In campus planning it is desirable to take the birds into consideration for the same reasons as in park planning. In addition there is the important objective of keeping up an important educational resource. There is hardly an advanced school in the country that does not offer one or more courses of bird study. The study of birds out of doors is essential to a good bird course, and this need should be kept in view by those in charge of college and school grounds. Sylvan campuses where formerly birds abounded have been so filled with buildings, so gardened and formalized, that birds are now scarce. If possible, some corner (preferably of original woodland, where that exists) should be allowed to run wild. Judicious addition of food-producing plants should be made there, and the campus in general improved for birds by allowing shrubs to make natural growths. Providing nest boxes would make up for the hole-eliminating activities of the tree surgeon. Winter feeding

³ Farmers' Bulletin 1087, *Beautifying the Farmstead*, may be consulted to advantage in connection with improving school grounds.

would be very interesting and instructive to many students and could be carried on as part of the course of bird-study classes. Finally, the teacher of ornithology might well serve in an advisory capacity in relation to the planning and treatment of the campus.

CEMETERIES

Cemeteries have the reputation of being good places for birds. The reasons, one must infer, are seclusion, freedom from disturbance, and an abundance of trees and shrubs. The last-named factor is by no means least, nor, on the other hand, so satisfactory as not to be susceptible of improvement. Selection of shrubs and trees with the needs of birds in mind not only would not interfere with the general plan of a cemetery, but would make it a still better resort for birds.

Formal landscape gardening is more prevalent (perhaps excusably so) in cemeteries than in other public reservations, yet there are beautiful cemeteries in which formal composition plays little part. Here, as everywhere, the informal or naturalistic planting is most favorable to birds. Nest boxes can be added without being obtrusive, and bird fountains may be made to harmonize with the surroundings or even to serve as memorials.

RESERVOIRS

The grounds surrounding reservoirs of drinking water usually are well fenced and carefully guarded to minimize contamination. This results in freedom from disturbance, a boon so highly appreciated by birds that in itself it goes far toward making these places satisfactory bird havens. Such reservations can be greatly improved for this purpose, however, by the use of bird houses and by proper planting, measures that will be in no way deleterious to the water supply, but will greatly benefit the birds and through them the vegetation of the reserve and of the adjacent country.

Reservoirs other than for drinking water usually can be sown to aquatic plants, which will make them attractive to many water birds. The character of the planting will depend on circumstances; if a marshy margin is permissible, the place may be made into an excellent resort for wild fowl. If only submerged plants are desired and as clean a growth as possible, sago pond weed may be planted. Broader-leaved plants furnish much greater surface for the lodgment of silt and the growth of algae.

GOLF COURSES

There are numerous public golf courses, and many of those established by clubs are so surrounded by residences of members as to become virtually community institutions. Golfers as a class are broadly interested in the out of doors, including its animal inhabitants, and most of them no doubt will be glad to cooperate in the preservation, encouragement, and increase of useful birds. In fact, considering the well-known utility of birds in destroying insect and other pests, golf clubs will only be furthering their own interests in preserving and propagating these natural enemies of the foes of their greens and fairways.

Golf courses, without special modification, present several features that are attractive to birds. The broad expanses of short grass on

the fairways furnish excellent feeding grounds for robins, meadow larks, European starlings, flickers, and killdeers. The longer grasses and weeds of the rough, and scattered clumps of trees and shrubbery open to full light, support an abundant insect population, an important source of food for our feathered friends. Many birds find nesting sites also in the arborescent growths present and sally forth for food over the grassed areas, where they are often joined by numbers of those aerial feeders, the swallows and swifts, which find on these unobstructed reaches happy hunting grounds.

Such are the impressions from observations made on a golf course well situated for birds. There are courses not so fortunate, but all have the fundamentals of valuable bird refuges. Protected to a considerable extent from trespass, and relatively free from the natural enemies of birds, golf courses already have much of the safety required for sanctuaries. Birds promptly respond to protection; but it should be as complete as possible. So far as food is concerned, insects are plentiful on most golf courses, but it would help the birds and ornament the courses if shrubbery on the grounds were selected chiefly from species producing fruits fed upon by birds. Most golf courses, again, have water hazards at which birds can drink and bathe; but where these are absent or are far apart, bird fountains could easily be attached to hydrant supply pipes. These not only would be a boon to birds on hot summer days, but if placed in view of rest benches would be a source of interest and entertainment to members and visitors.

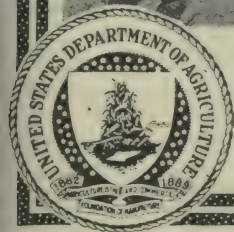
Protection, food, water—these are the things that usually are present in some degree and that may very easily be supplemented; but nesting sites, especially for some of the most useful birds, are scarce or lacking on most golf courses. Trees and shrubbery (the latter best if in tangled masses) will accommodate many birds; but the birds that nest in cavities can hardly find a home on improved lands, especially where tree surgeons have been employed. Fortunately these birds will occupy artificial cavities or nest boxes.

In most cases nest boxes must be supplied if golf courses are to be enlivened and benefited by such beautiful and useful birds as the purple martin, the bluebird, the house wren, the tree swallow, the flicker, the white-breasted nuthatch, and the chickadee. At least twice as many other kinds of small birds have been known to occupy nest boxes. Placing nest boxes is work that can well be done in winter, a season during which, at least on northern courses, employees are but little occupied, and when members may welcome something to do out of doors.

U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1645

SUGAR-BEET GROWING UNDER IRRIGATION IN THE UTAH-IDAHO AREA



THE CONSISTENT PRODUCTION of increased tonnages of sugar beets of satisfactory quality per acre is the logical solution of certain pressing problems confronting both growers and sugar factories in the beet-growing areas. To this end recommendations of improved methods of beet growing are made and practices that have been found most satisfactory for the beet-growing regions of Utah and Idaho are outlined.

There is definite experimental evidence, the result of several years' work, to show that present beet-cultural practices are inferior to methods herein described, and that the adoption of these better practices will lead to an increased production of beets per acre without increasing the cost per ton.

Likewise, certain recommendations are made concerning the handling of the crop in years when curly top is prevalent as contrasted with years when that disease does not appear. It is believed that such information will prove to be of great benefit to the industry. Attention is also directed to the benefits from more complete utilization of sugar-beet by-products on the farm.

This bulletin supersedes Farmers' Bulletin No. 567, Sugar-Beet Growing Under Irrigation.

SUGAR-BEET GROWING UNDER IRRIGATION IN THE UTAH-IDAHO AREA

By S. B. NUCKOLS, *Associate Agronomist, Office of Sugar Plants, Bureau of Plant Industry*

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INTRODUCTION

THE GROWING of sugar beets for the manufacture of beet sugar has been an established industry in the irrigated region of the United States for almost 60 years. (Fig. 1.) During this period the area devoted to the culture of sugar beets has increased and new factories have been built. Some sections have shown a steady development of the beet-sugar industry, while in some others the attempts have not been successful. In some areas in which beets have long been grown the industry now utilizes practically all the land suitable for beet growing, and in other areas where suitable land might permit expansion of the industry crop competition is checking the increase in sugar-beet acreage. For many factories the situation to be faced is the securing of a large enough tonnage of beets of satisfactory quality for economical sugar production. In those areas where the expansion in acreage is definitely precluded, it is evident that the production of more tons of beets per acre is the logical solution of the pressing problem. As an improved situation in pest control develops, as irrigation projects are completed, thereby opening up new land, and as research in soil and cultural practices makes greater land utilization possible, an expansion of the beet industry may confidently be expected. There is, however, an urgent need for greater attention to the improvement of yields in the present areas of sugar-beet growing.

From the point of view of the grower, an increased yield of sugar beets is essential to more economical crop production. There are many opportunities for profitable improvement in the present methods of sugar-beet growing. The average yields for the areas in the irrigated territory under consideration are from 10 to 12 tons per acre, but there are growers in all of the irrigated areas who, by utilization of the best cultural methods, produce more than twice that quantity. It is reasonable to assume that many growers who now produce less than the maximum possible crop could by changed methods greatly increase their yields. There is experimental evidence to show that many of the practices of sugar-beet culture are inferior to other more desirable methods which produce increased yields without additional cost. The basic costs, such as land rental, seed, and many of the items of crop handling, are approximately the

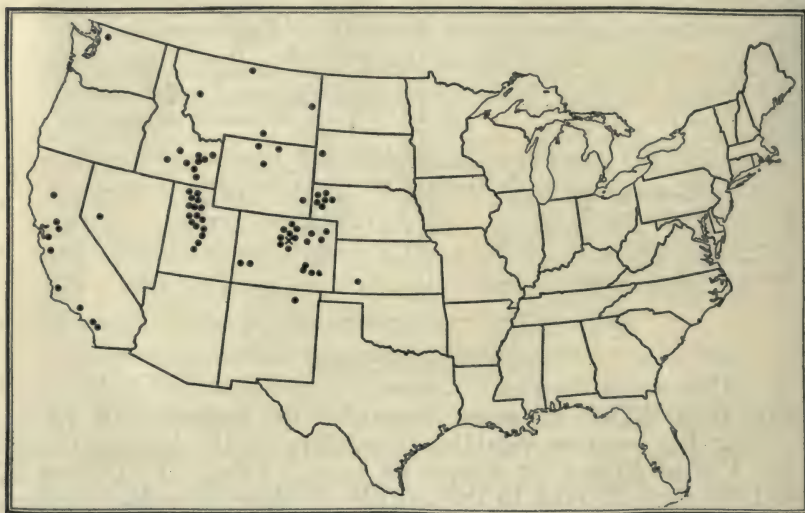


FIGURE 1.—Map showing (by dots) location of western beet-sugar mills. In the areas surrounding these mills more or less irrigation is necessary for the successful production of sugar beets. The X indicates a factory for recovery of sugar from molasses

same per acre for a low yield as for a high yield. The purpose of this bulletin is to present in brief form an outline of methods of beet growing which represent the most successful practices for the Utah-Idaho area.

CLIMATIC INFLUENCES

While all climatic factors have more or less influence upon the growing of sugar beets, temperature, rainfall, sunshine, wind, and humidity play the important rôles. Extreme variation in any of these factors may make an area unsuitable for sugar-beet culture, because these extremes of climate often cause serious crop injury. Storm periods, freezes, and periods of drought are common causes of reduction in the yield of sugar beets.

The sugar beet needs a growing season of at least five months. Areas that have an average temperature of 70° F. for three summer

months and only slightly lower average temperatures for the spring and fall periods are generally best adapted to sugar-beet culture. Regions with even temperatures are better adapted for sugar-beet growing than areas where there are excessive variations in temperature. High temperatures are considered harmful to sugar beets, but there is a lack of exact data upon this point. There is a general impression, however, that temperatures exceeding 100° are harmful, as the fields usually fail to make a good growth during these periods of extreme heat.

On the other hand, extremes of low temperature affect the beet crop. Beets are more resistant to frost injury than most of the crops grown in the irrigated areas. Young plants at their first appearance above the ground are sometimes damaged by frost, but larger plants are not usually killed unless the temperature falls below 27° F. Young plants suffer most injury from prolonged periods of cold weather during which there is a lack of sunshine. Cool weather in the fall is an important factor in bringing about storage of sugar. Light frosts during the ripening period hasten maturity and probably do little appreciable damage. Heavy freezes during the harvest season usually do not greatly injure the crop, if it has properly ripened, but they interfere with harvesting. During freezing weather precautions should be taken to prevent the freezing of beets that are piled in the field.

RAINFALL

Rainfall conditions have a profound effect upon the sugar-beet crop. The average annual rainfall in the irrigated region is usually less than 14 inches. The distribution of the rainfall throughout the year is exceedingly important. Many of the rains are light and have little effect on the soil-moisture content, hence they do not reduce the need for crop irrigation.

The rainfall in the winter and early spring months serves in many areas to store sufficient moisture in the ground to facilitate proper soil preparation. Fall plowing, as discussed later, influences the soil-moisture content appreciably. In some sections there is sufficient moisture in the soil or ample rainfall in early spring to germinate the seed when planted. However, in the greater part of this region there are occasional years in which there is insufficient moisture to bring about full germination of the seed. As a whole, growers in the irrigated areas put too much reliance on rainfall and fail to irrigate the beet crop sufficiently following planting and in the early stages of the crop. A forward step in sugar-beet growing in the irrigated area will be taken when the practice of prompt irrigation following planting is generally adopted. The rainfall during summer and early fall is usually light and may occasionally serve to reduce the number of irrigations necessary. The rains during the harvest season are beneficial in keeping the ground moist enough to facilitate pulling the beets. As will be seen in the discussion of irrigation practices, the amount and distribution of rainfall needs to be carefully considered in connection with applications of irrigation water.

WIND

Other climatic factors also need to be considered in connection with the sugar-beet crop. One of the most important of these is wind. In this western region drying winds increase evaporation from the plants and the soil. Since this region is one where a deficiency in natural rainfall exists, the greatest problem confronting the grower is one of supplying water to the crop and securing its retention in the soil. High winds, such as prevail after a rainy period, often bring about rapid drying of the soil and the formation of crusts, especially on heavy lands. Early restoration of the mulch by the use of the harrow, cultivator, or other especially adapted tools benefits the crop.

A type of wind effect, aside from drying, needs also to be mentioned. This is specifically known as wind injury or sand blast, which occurs on young plants exposed to the grinding effect of sand particles driven along the row by the wind. Such injury to beets is most serious on excessively sandy soils. Certain small areas are so subject to this wind injury in early spring that they are unsuitable for beet growing. Wind damage on sandy soils may be partially controlled by top-dressing the land with manure, plowing or harrowing when wet, planting the rows in the direction at right angles to that of the prevailing winds, and by the use of irrigation ditchers on the seeders. On other types of land a heavy rainstorm causes sand particles to lie on the surface of the soil in such a manner that they are easily picked up and shifted by windstorms. Under such conditions it is advisable to harrow or cultivate the field as quickly as possible after the rain.

HAIL

Agricultural crops grown in the western region frequently suffer from hail. There is no crop available for culture in this region which is able to recover from hail damage so successfully as sugar beets. Storms occurring in early spring cause the greatest damage because the small plants may be killed. Hail later in the season destroys only the leaves of the plants, the roots surviving. New leaves are then thrown out and the crop continues to grow. Under such conditions, although growth is checked during the replacement process and the crop is delayed, more or less recovery from the hail damage ensues. This is in marked contrast to the excessive loss suffered by other crops exposed to hail damage. This ability to recover from hail injury is an important feature of the crop, which makes the sugar beet valuable for the intermountain area of the United States in which hail injury frequently occurs.

FIELD SELECTION

LAY OF LAND

Not all soils nor all fields of an area in which beets are grown are suitable for beet culture. Careful consideration should therefore be given to the contours of the field, soil type, fertility, and the physical condition of the soil. Generally, the best sugar-beet lands in the irrigated region are those that have a gradual uniform slope

which allows the economical use of irrigation water. Fields that are uneven as to slope present many difficulties in row irrigation and should not be planted until properly leveled. Uneven fields are difficult to irrigate, as the low portions are flooded and the crop is damaged either by the washing and crusting of the land or by the scalding of the beets. Fields with a decided slope are inclined to wash badly when irrigated, and in order to secure sufficient storage of water in the soil excessive amounts of water are wasted. Proper utilization and conservation of irrigation water is essential. Better irrigation of some sloping fields sometimes may be secured by laying out the field so that the rows run at an angle with the slope. On flat fields, where the texture of the soil is such that the penetration of water is rapid, relief is found in shortening the run of water by spacing the laterals closer together.

SOIL TYPE

The type of the soil must be given consideration in the selection of fields for sugar-beet growing. The characteristics of certain soils are such that they may be rendered suitable for beets by proper preliminary handling, but in some cases the soils can not economically be made suitable for sugar-beet growing. Great variation in soils is found in the irrigated areas, the soil types ranging from heavy clay, medium clay, silt, sandy loam, pure sand, adobe, and volcanic ash to gravel soils. Most of these are slightly alkaline. The light and intermediate loams are best adapted to sugar-beet culture, as they are more easily handled, are least subject to serious crusting, and further, these soils usually produce better crop yields than other types. Very loose soils absorb water rapidly but do not retain it well, while very heavy ones absorb water slowly and retain it longer. The ability of a soil to absorb and hold water is very important in the irrigated areas. Heavy clays are somewhat better adapted to sugar-beet growing in the irrigated areas than is the case with beets grown under conditions of natural rainfall. The heavy clays are difficult to handle when either wet or dry, but as the irrigated region is generally one of light rainfall, the clay soils are seldom too wet for effective cultivation if proper control of moisture content through the application of irrigation water at suitable times is maintained. The clay soils generally are more subject to crusting and other adverse conditions than are the looser soils. Fields in which the soil is of a heavy clay nature should have only slight slope, as water penetrates soil of this type slowly.

Beets on very sandy soils usually mature early and produce light yields unless irrigation water is abundantly supplied and a good state of fertility is maintained. Such soils should be irrigated in short rows, because the water penetrates rapidly. The unfavorable characteristics of sandy soil in relation to wind damage have already been mentioned. Beet plants start earlier in the spring on sandy soils and have a more vigorous growth during the first few weeks of the season. Unless care is taken, the beet crop on sandy soils may suffer from lack of moisture and from the effects of hot weather. The growing of beets on gravelly soils presents many of the difficulties discussed for sandy soils. It is frequently difficult to get a good stand of beets on gravelly types of soil.

The physical condition of the soil depends chiefly upon its type, previous handling, and previous cropping history. The physical condition has a close relation to the fertility of the soil, and this in turn depends largely upon previous handling. Fields may be improved by proper preparation of the seed bed, but the effects of crop rotation, drainage, and manuring are fundamental. Water-logged soils or soils lacking humus can not be easily improved by the normal operations of preparing the seed bed. Fertile soils with adequate water-holding capacity are easiest to keep in good physical condition. Soil for beets should be such that the fields can be quickly prepared for early spring planting. Fields that are difficult to prepare delay planting and require the expenditure of excessive amounts of labor. Soils of different types require varied means of preparation. Heavy soils are inclined to be too firm and light ones are inclined to be too loose for good seed beds, while medium loam soils are the easiest to place in proper physical condition for the planting of sugar-beet seed. Alfalfa or other sod lands are difficult to put into good physical condition and should be planted to some other crop for one year before being planted to beets, unless the returns are sufficient to pay for the extra labor of properly fitting such lands for beet growing.

The character of the subsoil must be considered in the selection of lands for sugar-beet growing. Its structure influences the height of the water table. It must be porous enough to allow ample drainage and at the same time not be so porous as to allow too great a loss of water through underground drainage. Because the beet is a deep-rooted plant it is imperative that the subsoil furnish its share of the moisture and plant-food elements. A subsoil that has a hardpan covered by 18 inches or less of good surface soil is not suitable for beets, and the same is true of fields with a shallow layer of soil over a loose, gravelly subsoil. The ideal beet field is one having a good depth of a fertile soil underlain by a subsoil of medium structure. Such soils permit slow and ample drainage of excess water, sufficient root penetration, and ample depth of feeding area for the plants.

IRRIGATION

The selection of irrigated lands for sugar-beet growing is not fully considered until a thorough examination of the irrigation water supply has been made. Land and irrigation water are sold as one item in most areas; and the value of the land for beets is largely dependent upon the water supply, for sugar beets must have an ample supply of water during the latter part of the crop season. The first irrigations depend largely upon the normal flow of the streams of the area, while the later irrigations are accomplished by the use of stored waters. As a whole, the streams of this area have a heavy flow of water early in the year when the snows of the higher altitudes are melting. These snows are mostly melted before midsummer, and the flow of the streams then diminishes rapidly. Alfalfa and grain crops can be irrigated easily by such waters, but the beet crop needs water later in the season. Only a limited acreage of beets could be grown in the irrigated areas without storage of the flood waters. Moisture can be stored in the soil in addition to that which is stored in the reservoirs. If the soil is not too wet it is well to practice irrigation in times of abundance of water, in order that the crop may

not need to call on the reservoir supplies so soon after the stream flows diminish.

Beets grow best when supplied with ample moisture. Excessive or deficient irrigation seriously injures the crop. Moderate irrigations applied at frequent intervals seem best for sugar-beet growing. The total quantity of water applied or the quantity used at any one irrigation varies for different climates and soils. Light sandy soils require more water than heavy soils. A shallow sandy soil is able to absorb and hold only 2 or 3 inches of water, while a clay loam can absorb and hold 5 or 6 inches or more of water at one irrigation. On sandy soils it may be necessary to irrigate every week during the summer months, while on other types there is no necessity for such frequent irrigations. Where irrigation water is limited, it is best to apply the bulk of the water during the middle of the growing season, rather than early or late, provided irrigation is unnecessary in order to germinate the seed. At one time there were popular opinions to the effect that irrigating the sugar beets early in the season prevented deep rooting, and that late irrigation reduced the sugar content of the beets. It has been found that these opinions are not based upon facts. The beets should be irrigated whenever the leaves turn a dark-green color or begin to wilt in midday and do not quickly recover at night. This is true whether the beets have only a few leaves or are nearing maturity. Early irrigations should not be as heavy as those later in the year. Many growers irrigate only in alternate rows when the beets are small. This is sufficient, especially on lands that subirrigate rapidly.

The following general comments on irrigation practice throughout the growing season will outline the usual methods followed in growing the sugar-beet crop. In some localities it is necessary to irrigate before or immediately after planting. In irrigating before planting, furrows are run 20 to 40 inches apart, depending upon the type of land (fig. 2), and the field is then irrigated. As soon as the land can be worked it is smoothed down and the seed planted. Where irrigation follows planting, it is advisable to attach ditchers to the drill to furrow the rows. Occasionally the soil type is such as to require that each row be furrowed, but usually irrigation applied in the alternate rows is sufficient. The furrows should be deep enough and smooth enough to insure a free flow of water between the rows without flooding, and the application should be continued long enough to bring about thorough moistening of the seed. It is not advisable to give a heavy irrigation at this time if the seed can be thoroughly moistened by a moderate application. As soon as the land dries it should be harrowed or cultivated. After the plants emerge and throughout the summer the beet crop should be irrigated before it suffers from the lack of water. Approximately 60 per cent of the space between the soil particles should be occupied by water for best results. Hot days and high winds increase and seasonal rains reduce the need for irrigation. Very fertile soils require somewhat less water per pound of crop produced as compared with soils of low fertility. It should be kept in mind that the beet plant can not absorb food from the soil except when these basic food materials are in solution. The beet feeds through the delicate root hairs which clothe the fibrous roots, and since many of these feeding roots

are in the upper areas of the soil, it is imperative that sufficient moisture be present in the feeding area to prevent reduction of food consumption by the plant through lack of water.

Care should be taken to distribute the water evenly in all furrows and to give all parts of the field an equal irrigation. If the distance between laterals is very long, the application of irrigation water may be uneven and water wasted. Washing and flooding are often caused by running too great a volume of water in a furrow. Flooding should be avoided in all cases, as it wastes water, forms crusts, and sometimes scalds the beets. The furrows and waste ditches at the lower end of the field should be watched closely to see that they do not become clogged and cause flooding. The beets should be irrigated late in the season, if necessary, to keep them in a growing condition. At digging time the soil should be in a good friable tilth, since where the soil is very dry there is a loss of roots by breaking, and on the other hand, if the soil is wet, mud clings to



FIGURE 2.—Ditching a sugar-beet field in preparation for irrigation of the seed bed before planting. Deep, straight furrows are essential to good irrigation

the beets, thereby increasing the tare. Therefore, the last irrigation should be timed so as to bring the land into good condition for harvesting. If during the harvest season the field becomes too dry, it is sometimes advisable to irrigate very lightly. Such a practice does not ordinarily reduce the quality of the beets.

DRAINAGE

Irrigated areas usually lack artificial drainage systems to dispose properly of the excess waters from irrigation and canal seepage. Lands that do not have good drainage are subject to increasing alkalinity. Some lands that once grew good crops have become so alkaline that they have been abandoned for beet growing. Such lands can be slowly reclaimed by the building of a proper drainage system and washing the land by abundant applications of irrigation water. It is better to install the drainage system before the land has

deteriorated. Adequate drainage can be provided by the use of tile or of open ditches. The initial expense is greater for tile drainage, but the maintenance is less if the system is properly installed. Open ditches are more wasteful of land, present a weed problem, and often cause irregular-shaped fields, all of which collectively tend to increase the cost of crop production. No rule can be given for any special type of drainage, as there are many local factors which must be considered. Tile drains should be placed in the ground below the deepest plow furrow, and at the same time should be placed near enough the surface to be quickly reached by the surplus waters. The drainage system must be installed so as to lower the water table from 3 to 4 feet below the surface of the soil and to carry off surplus surface and subsoil water to approximately the same depths. Local conditions and types of soil must be fully considered in the installation of a drainage system, as in some areas a much deeper tiling system is necessary than in others. There are areas and soil types where an open-drain system is the only feasible method of drainage. In some areas where the water table is high it is a common practice to make use of this for the subirrigation of beet crops. This method has been occasionally successful in some places, while in other areas it has caused the deterioration of large acreages due to the quick increase in alkali salts at the surface. A great many of the subirrigated areas should have drainage systems installed.

Excessive moisture content in the soil is not favorable to sugar beets. The young plants on such soils are most frequently damaged by root rots commonly called "blackroot." These or similar rot diseases continue to attack the crop throughout the season. High water tables also cause the beets to grow branched roots instead of the normal straight taproots. During dry seasons some of these wet lands are improved by the lack of rainfall and produce excellent beet crops. During wet seasons, however, the crops on such lands are the first to suffer from excess water. Wet lands are usually difficult to prepare early in the spring, and sometimes are too wet for proper harvesting in the fall. Such lands would be greatly improved by adequate drainage which would tend to equalize the water content of the soil. Not all soils that are naturally drained are good for beet growing under irrigation. This is especially true of those soils that are of loose sandy or gravel composition underlain by a subsoil of similar type. Such soils do not retain sufficient moisture for good crop growth.

CROP SEQUENCE

Any crop has a characteristic effect upon the soil in the nature of soil depletion, and in addition when it is continuously grown on the same field, injury from disease and insect pests as well as from weeds is intensified. The continuous growing of sugar beets often produces such unfavorable conditions for beets as to make the practice extremely undesirable. Since the growing of sugar beets leaves the soil in excellent condition for growing other farm crops, and since in like manner many other crops produce soil conditions very favorable for subsequent beet growing, a proper crop rotation is very desirable.

It is true that there are some successful plantings of sugar beets where the land has been used continuously several years for beets.

Such plantings are successful, however, only where the fields have had heavy applications of manure and the land has not become infested with the sugar-beet nematode. The application of all of the manure on one field benefits only one field at the expense of the other parts of the farm. Continued cropping to sugar beets almost invariably results in the land becoming infested with the sugar-beet nematode and the garden nematode, and eventually the single-cropping system leads to serious losses to the grower.

The type of rotation to use in connection with sugar-beet growing varies for different farms and different sections. The value of the other crops has much to do with their use in the rotation. Short rotations, such as grain and sugar beets or grain and alfalfa, are not usually so successful as longer rotations. In the case of fields infested with the sugar-beet nematode, beets should not be grown at less than 4-year or 5-year intervals. The long rotation which is desirable can be obtained by using some leguminous crop such as alfalfa, which, if not maintained too long, assists in keeping up the nitrogen content of the soil. Crop rotation should be so arranged as to give good seasonal distribution of labor. A rotation system which provides green crops to be plowed under is beneficial.

Several systems of rotation practice are successfully used. The crop sequence to be adopted depends on the type of farming practiced and whether or not the soil is infested with the sugar-beet nematode or other parasites. Where such infestation is prevalent, it is necessary to increase the period between the beet crops correspondingly. An example is seen in the 10-year rotation.

The rotation may be lengthened by the repetition of the cultivated 1-year crops before, after, or between the beet crops, or by continuing the alfalfa for a longer time if nematode infestation is serious. Some green growth should be plowed under at the close of the hay-producing period, and, where practicable, green-manure crops should be added to the rotation. In general, the following rotations are applicable to the irrigated areas under consideration:

5-year rotation		10-year rotation	
	Years		Years
Grain and red clover.....	1	Grain and alfalfa.....	1
Red clover for seed.....	1	Alfalfa.....	3
Miscellaneous (such crops as onions, potatoes, grain, melons, peas, corn, etc.).....	2	Potatoes.....	1
Beets.....	1	Beets.....	1
		Miscellaneous (such crops as beans, grain, etc.).....	3
		Beets.....	1
8-year rotation			
Grain and alfalfa.....	1		
Alfalfa.....	3		
Potatoes.....	1		
Beets.....	1		
Beans.....	1		
Beets.....	1		

MANURES AND FERTILIZERS

All plants take certain elements from the soil and use them in the various structures of the plant, and when the crop is removed the soil is depleted to some degree. The amounts of these elements

removed depends upon the crop grown and the yield. Sugar beets remove certain plant foods from the soil, and in order to maintain maximum production these elements must be replaced in some manner. This replenishment is accomplished by the use of barnyard manures, commercial fertilizers, green-manure crops, and by the return of crop residues to the soil. These methods of maintenance of soil fertility need to be considered for the intermountain region. The use of barnyard manure in connection with the sugar-beet crop is a common practice. The plowing under of green crops is second in importance. The use of commercial or mineral fertilizers, although a standard practice in other beet-growing territories, is not yet fully developed in the intermountain region. It is improbable that beet growing can be continued there in a successful manner without an increasing use of all these methods of maintaining and improving soil fertility. The future cropping practices of the intermountain region will undoubtedly make use of all three types of treatment for this purpose.

MANURES

The use of barnyard manure in connection with the sugar-beet crop is a common practice. In many places such manure is not available in sufficient quantities to supply the need for humus or vegetable matter in the soil, and green manure must be plowed under as a supplement. Manure has another value other than the building up of the organic content and the returning of minerals to the soil, in that it affects the bacterial content of the soil, producing a so-called quickening action. Many of the soils of the Utah-Idaho area are high in plant foods, but these often occur in a form not readily available to the plant. The effect of green manure and barnyard manure is to make plant food available from the soil reserves. The use of crop residues can be attained most efficiently either by pasturing stock in the beet fields, as discussed later, or by utilizing manures from stock fed in a feed lot.

GREEN MANURES

The most valuable green-manure crops for use in this area are sweetclover and alfalfa. All rotations should include at least one green crop to be plowed under. The above types of green-manure crops build up the organic and nitrogen content of the soil. There seems to be little need for the purchase of mineral fertilizers excessively high in nitrogen where legume crops are plowed under and manure from stock fed on legume hay is used. Examples of the benefits obtained by the use of green-manure crops are common in all of the irrigated sugar-beet region, and those of northern Colorado and western Nebraska are noteworthy. During the last few years these two areas have surpassed all others in the increased use of green-manure crops with a coincident improvement of sugar-beet yields.

COMMERCIAL FERTILIZERS

Experimental work with commercial fertilizers in the intermountain irrigated area has not reached the stage where a definite statement can be made as to the best practices to be adopted. In some cases, because of the high state of fertility of the soil, sufficient

increase in crop yield resulting from the application of commercial fertilizers has not been obtained to warrant recommending them. In other instances the failure to secure profitable returns has been due to improper methods of application of the fertilizers.

In experimental trials the best returns from mineral fertilizers have been obtained by applying fertilizer of high phosphate content in the row below the seed at planting time and lightly irrigating the land immediately. This method distributes the fertilizer in the soil, makes it available for the young plants, and prevents possible injury from the fertilizer. This is important, since in many instances where fertilizer has been applied and irrigation omitted the fertilizer remained dry and did not become quickly available to the plant.

In other beet-growing areas high-percentage superphosphate has given good returns. This fertilizer is generally applied broadcast in a grain drill with fertilizer attachment prior to planting the beet seed.

Since these methods have been found to be of value in other sections, it is very likely that they will eventually be found beneficial in the Utah-Idaho area.

PREPARATION OF THE SEED BED

A properly prepared seed bed for sugar beets is deep, moist, and firm. The soil should be worked to a fine texture, and it should be smooth and level. Beet seed is properly planted when placed in moist soil about 1 inch beneath the surface in a seed bed that is deep enough to supply ample feeding area for the beet, which is a deep-feeding plant. Moisture is required to germinate the seed and to supply the young plants. Commercial fertilizers if used in the row with the seed furnish readily available food materials to promote rapid growth of the seedlings. A firm seed bed makes planting to an even depth possible, avoids future settling of the soil, assures even distribution of moisture, and affords a good contact between the seed and the soil. A seed bed of fine texture does not obstruct the roots in their natural growth. The seed bed should be level so that the depth of the planting will be even and the land can be properly irrigated. With beet seed planted in a good seed bed, a perfect stand and a good crop is obtainable, but with a seed bed lacking in any one of the requirements enumerated above there is much danger of a poor stand and a correspondingly lower yield. Many of the difficulties of seed-bed preparation are avoided by timely and proper performance of all operations.

A number of common farm implements are used in seed-bed preparation. There is some variation in their use, but in general it is necessary to use the turning plow, the disk, the spike-tooth harrow, and the leveler. The roller and the spring-tooth harrow are occasionally useful. They are especially useful when dry-soil conditions prevail which make compacting of the soil surface necessary or when it is advisable to pulverize a cloddy soil surface to a proper fineness.

PLOWING

Plowing is done to bring about a thorough turning, stirring, pulverizing, and mixing of the surface soil to a desired depth. The more thoroughly this is accomplished during plowing, the less labor

there is to be done with the other implements. The furrow slice should be cut to an even depth and to the width of the cutting edge of the plow. It is best to plow when the soil contains such an amount of moisture that the furrow slice will break and crumble when turned. Plowing when the soil is dry leaves clods, while wet plowing packs instead of stirring the furrow slice. In some areas the winter supply of moisture is insufficient to moisten the large clods, and it is difficult to prepare a satisfactory seed bed. (Fig. 3.) Such dry lands should be irrigated before plowing and, where possible, disked before plowing, to avoid crust formation. Careful harrowing or disking as soon as the land is plowed will save much work later. The modern 2-way plow is best for land that is to be irrigated, as it does not leave any dead furrows in the field. Subsoiling is not commonly practiced in the Utah-Idaho area. On some types of soils it might be profitable, but as a whole it has not as yet been considered essential.

Fall plowing has many advantages over spring plowing. Fall-



FIGURE 3.—A field plowed when very dry. The dry, hard clods remained in the field over winter. Unless sufficient moisture is applied to soften the clods, a great amount of labor will be needed to make a proper seed bed

plowed land retains winter moisture well. With the land thus prepared, early preparation of the seed bed and timely planting are possible. As a rule, fall-plowed lands produce the better yields. Since spring plowing must be hastily done, the land does not have time to pack properly before the seed is planted. Spring-plowed lands have many dry spots because they lose moisture while being turned. Although disking the land and planting the best seed without plowing permits early planting and saves moisture, this practice should be used only in extreme emergencies. Usually a much better crop is produced by fall plowing and an orderly system of seed-bed preparation.

Beet land should be plowed to a depth of 10 or 12 inches wherever previous practice and the soil type permit. Plowing to this depth forms a deep seed bed, destroys certain insects, and turns under some weed seeds to a depth that prevents their germination. Land not previously plowed deeply should be plowed not more than 1 inch

deeper each year until it eventually is turned to a depth of 10 to 12 inches.

CROWNING AND REPLOWING

In the irrigated areas alfalfa and sweetclover are common crops, and much of the land devoted to these crops is later planted to sugar beets. Alfalfa and sweetclover are excellent crops to grow in a rotation with beets, as they are a very valuable source of nitrogen supply. The roots of these plants, however, are often damaging to the subsequent beet crop. In a rotation using these crops, when the land is properly prepared for the planting of sugar beets the yields are very satisfactory, but where the land is poorly prepared failures are frequent. Since following alfalfa or sweetclover with beets presents these problems in soil preparation, the use of some other crop such as potatoes, beans, grain, or peas is advised. Several methods have been used to prepare alfalfa and sweetclover sod lands for sugar beets. Plowing when the plants are in the dormant stage leaves intact many of the roots, which send forth shoots that become troublesome as weeds the following season. If only a single plowing is given while the plants are dormant, it is best to grow grain on the land one year and to plant the field to sugar beets the following year. Double plowing cuts the alfalfa roots in short lengths. The first operation consists of a crowning or shallow plowing.

The crowns are allowed to dry for a period of two to six weeks and are then replowed to a depth of 8 to 12 inches. This process turns the heavy crowns deeply into the ground, where they do not interfere with cultivation; it also kills most of the plants. A better method is to plow while the crop is in a growing condition. Plowing in late August or early September is best, as the ground is warm and the turned-under green manure rots quickly. In this manner all of the roots and plants are destroyed, and their decay adds to the plant-food supply for the following crop. Sweetclover should be plowed somewhat earlier than alfalfa, so as to make certain that none of the plants are in a dormant stage. If the plants are left until spring to be plowed, they should be allowed to grow until the sprouts are about 12 inches high. It should be remembered that this delay in the spring often interferes with a safe planting schedule for sugar beets. However, where such crops are plowed under and the land is promptly irrigated, so as to rot the alfalfa or sweetclover quickly, this has been found to be a better practice than plowing these crops while in the dormant stage.

In some sections it is a common practice to plant crops such as potatoes or beans, rather than sugar beets, on spring-plowed alfalfa or sweetclover sods. The fact that these plants have a later planting date allows for more green growth and also more time for the preparation of the seed bed. This is a good practice, and under proper crop-rotation systems it provides fields in good condition for use for the sugar-beet crop.

HARROWING

The spike-tooth harrow is one of the most useful implements in the preparation of the seed bed. It may be used to break clods, to form a soil mulch, to destroy small weeds, to assist in leveling

the land, to prevent crusts, and to conserve moisture. Harrows are made in various sizes and shapes and with different sizes of spike teeth that can be adjusted at different angles. It is good practice to harrow all lands as soon as plowed, while the furrow slice is still in a friable condition and before dry clods have formed. One harrowing at this time accomplishes more than several later ones. In case of delayed planting, the field should be harrowed as often as necessary to keep the surface free from crusts and to kill weeds. Whenever beet land is leveled or smoothly rolled it should be harrowed immediately to form a light mulch on the soil. This prevents crusting and loss of moisture and reduces the possibility of blowing or shifting of the fine soil surface. All beet lands should be harrowed just previous to planting.

DISKING, ROLLING, AND LEVELING

Disking before plowing is an essential operation and should be practiced whenever possible. The disk is also a useful implement for stirring the soil to shallow depths and incorporating manure with the soil. It is especially useful in breaking up clods. In the case of fields that are foul with weeds, certain modifications of normal practices are sometimes desirable. Although in most cases it pays to plant the field of beets very early, in the case of foul fields it is suggested that planting be delayed until the surface weed seeds have sprouted. The field should then be disked or cultivated to destroy the first crop of weeds. This practice must be looked upon as a control measure to reduce the number of weeds and as a general measure for field improvement. Land infested with wild oats furnishes the best example where the delayed-planting method should be employed. Such land should be given a shallow plowing in the fall so that the oats will sprout early in the spring. The land should then be plowed deeply and disked or harrowed with the spike-tooth harrow. At best the growing of sugar beets on land infested with wild oats is not likely to give a large crop, for this pernicious weed usually crowds out some of the young beets and reduces the stand.

Three types of rollers are used in preparation of sugar-beet seed beds in the irrigated areas—the smooth roller, the corrugated roller, and the subsurface packer. Where land is spring plowed it is sometimes necessary to roll the land to obtain a sufficiently firm seed bed and to improve its texture.

The box leveler in common use in the irrigated areas is a very efficient tool. (Fig. 4.) It fills up small depressions in the land, crushes clods, and packs the soil. A seed bed seldom needs to be rolled or subsurface packed if it has been spike-tooth harrowed and leveled. These box levelers should be 16 to 20 feet long, as shorter ones do not fill in depressions. The plank drag performs some of the work done by a leveler, but is less efficient. Land should be leveled twice after plowing, and the second operation should be done at right angles to the first. If a third leveling is necessary, it should be made in the direction of the planting. As the leveler is a heavy implement and has a packing effect upon the soil, it should not be used when the land is wet or before large clods are broken

by the use of the harrow. Leveling is one of the last operations of preparing the seed bed. After the land is leveled one light harrowing fits the land for the reception of the beet seed.

EQUIPMENT FOR PLANTING

Beet-seed drills are of various types, and each has its advantages and disadvantages. The efficiency varies under different conditions, and there is a considerable divergence of opinion as to what type of drill is the best. Any of the standard types do good work if adjusted properly and operated in an efficient manner.

There are two types of feeding arrangements on beet-seed drills—plate feed and force feed. The plate-fed drills are inclined to leave the larger seeds in the drill, which should be cleaned occa-

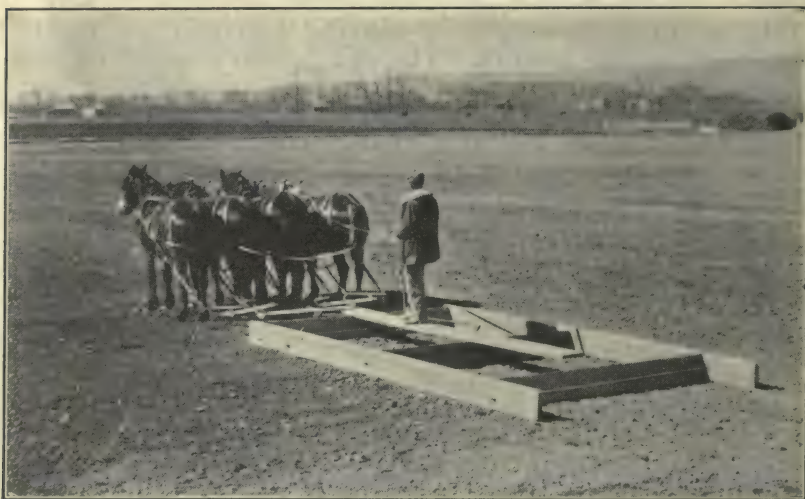


FIGURE 4.—The box leveler making a well-prepared seed bed. This illustration shows a number of items of importance in the preparation of a sugar-beet seed bed. The land has previously been leveled at right angles to the present leveling. The seed bed is so firm that the hoofs of the horses make only shallow, easily covered depressions

sionally, and the larger seeds planted with a plate having large holes. The force-feed drills need more care in adjustment to make certain that each spout distributes the same quantity of seed.

The covering arrangements are mostly limited to two types—the disk coverer and the shoe drills. The latter are more variable in type. The shoe drills depend upon the press wheels of two types, rigid and free, to cover the seed. It is usually possible to tighten the free press wheel so that it is rigid. With the rigid type the depth of planting is adjusted by the setting of the press wheels and the height of the tongue. When teams are changed or the tongue is raised by adjustment of the harness, it is necessary to recheck the depth of the planting. Since dull shoes do not plant so deeply as new ones, the adjustment of a drill is an individual operation for all used drills. Because of dragging the seed, some types of drill shoes plant seed at uneven depths. The actual per-

formance of the drill in the field should be watched carefully and adjustments made to fit the particular conditions.

Different sizes of seed are planted at different rates by drills. The ordinary method of checking a drill which is approximately correct is to plant a known acreage from a weighed quantity of seed and to weigh the remainder. The tongue of the beet drill should be stabilized to obviate play. Two straps or chains may be used to stabilize it. (Fig. 5.) This prevents the tongue from swaying and turns the drill back to proper position more rapidly than by depending entirely upon the harness. The rings in the ends of the neck yoke are fastened to the small rings on the inside hames of the opposite harness. The beet-seed drill should be care-

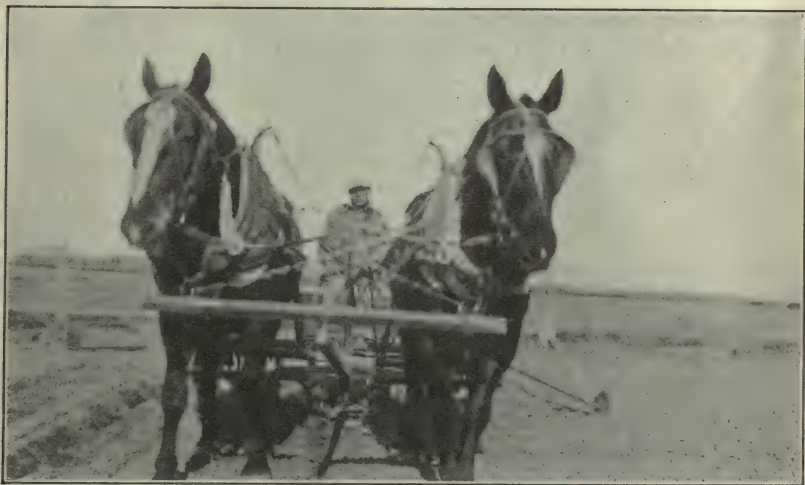


FIGURE 5.—A sugar-beet seed drill, showing attachment of chains from end of neck yoke to harness. This stabilizing device on the tongue is an aid in securing straight rows

fully adjusted and the following directions followed to secure its best performance:

Check the amount of seed planted by each drill spout separately.

Check the depth of soil penetration for each drill shoe separately, making necessary adjustments.

Set each drill shoe so that the depth remains permanently the same.

Tighten the neck yoke and straps so that the tongue does not sway up and down or sideways.

Check the setting of the marker device from both sides of the drill so that the proper guess-row width is obtained.

Clean the seed hoppers of a plate drill occasionally to remove large seed and any accumulation of seed trash likely to clog the plates.

Avoid planting wet ground with a shoe drill, as it will glaze and pack the seed row.

Determine that the press wheels firmly cover the seed in moist soil.

When the drilling of the main part of the field is completed, it is a good plan to cross plant the ends of the field used for turning, to keep down the weeds and to add to the productive area of the field.

FACTORS INFLUENCING STAND

DATE OF PLANTING

The important factors to consider in planting sugar-beet seed are date of planting, depth, quantity of seed, and proper mechanical placing of the seed in the soil. All of these factors are subject to some variation for differences in soils and climatic conditions. Beet seed is planted as soon in the spring as the soil conditions become favorable for its germination and growth. If other conditions are favorable, the beet seed will germinate well when the soil temperature is around 60° F. The young plants can withstand temperatures of 27° when the cold period is of short duration and the soil surface is moist, but it is advisable to delay planting until there is no danger of long-continued periods of cold weather. If the ground is wet and cold for a long period it retards the germination of the seed and the growth of the plants. In the irrigated areas such periods of weather are not of common occurrence, and early planting has, as a rule, given better results than late planting. The better yields resulting from early planting are partially due to the fact that early planting gives the beets a longer growing season. In curly-top years the advantage resulting from early planting may mean the difference between success and failure. Another factor in favor of early planting is the greater abundance of moisture early in the season in this region, which is subject to strong, drying spring winds that rapidly lower the moisture content of the soil. In some localities it is a common practice to delay planting a portion of the beet area so as to distribute the labor of thinning. It is doubtful if it is ordinarily profitable to delay planting if the land is in proper condition to receive the beet seed. Late planting is often more detrimental to yields than a corresponding delay in carrying on the thinning operations.

Beets that are planted very early are occasionally so seriously damaged by freezing or by other climatic conditions that it is necessary to replant the fields. It is often difficult to determine whether to replant or to continue with a partial stand. It must be remembered that beets frequently show unexpected powers of recovery, and there is no assurance that the replanted crop will have conditions favorable for a perfect stand. Where replanting is done, the beets have the disadvantage of a late start. In case it seems advisable to replant, it is generally necessary to irrigate immediately after seeding, in order to avoid any further delays. The variations in yields from date-of-planting tests illustrate the situations commonly met. For example, in 1926 a delay of 13 days in time of planting caused a reduction of 4.78 tons of beets per acre. In 1927 a delay in planting from March 30 to April 13 reduced the yield 0.47 ton per acre, and a further delay until April 26 gave a further reduction in yield to the amount of 1.1 tons per acre. In this season late planting was less detrimental than in 1926. The late planting usually produced beets with a lower sugar content than that of the early planted beets. It is evident that no exact date of planting can be given, since seasons vary so greatly; but experience in the intermountain region has shown that beets should be planted as soon as weather conditions permit.

DEPTH OF PLANTING

It is normally advisable to plant sugar-beet seed from 1 to $1\frac{1}{2}$ inches deep, and in only very special cases should the seed be planted less than 1 inch or more than $1\frac{1}{2}$ inches deep. Planting at one-half inch depth gives good results where the land is very moist and when there is no danger of drying winds. Planting more than $1\frac{1}{2}$ inches deep is considered necessary in some fields where there is a



FIGURE 6.—Sugar-beet seed planted at 3, 2, and 1 inch depths in a good seed bed. Note the straight growth of seedlings in contrast with the type of growth obtained with a poorly prepared seed bed (fig. 7)

lack of moisture, but deep planting frequently results in poor germination and weak plants. The general effects of planting at different depths and in a good and a poor seed bed (1, 2, and 3 inches) are illustrated in Figures 6 and 7. The 1-inch depth of planting in a good seed bed is far superior. In Figure 7 the detrimental effect of poor soil preparation is well illustrated. These illustrations represent what is being enacted on a large scale in the field and graphically typify the difference between the right and the wrong way of beet-seed planting.

RATE OF PLANTING

Not only the depth of planting, but also the quantity of seed to be planted, influences the yield of sugar beets. The quantity of seed varies with the condition of the seed bed, the climate, and the quality of the seed. In general, sugar-beet seed is of standard quality, and



FIGURE 7.—Sugar-beet seed planted at 3, 2, and 1 inch depths in a poor seed bed. The seeds planted 3 inches deep show the least vigor, and those planted 1 inch deep show the most vigorous plants. Note the lack of straight growth of stems and roots. These plants are 30 hours older than the plants shown in Figure 6

the quantity commonly planted per acre (15 to 20 pounds) is sufficient to furnish a satisfactory stand. Although a slightly smaller quantity of good seed planted under ideal conditions will produce a good stand, the few extra pounds of seed required for the heavier rate of seeding is considered cheap insurance against the danger of a poor stand. An extra quantity of seed will not make up for careless planting or poor preparation of the seed bed. There is sufficient

difficulty in obtaining a good stand of beets when one contends only with unavoidable damage. It sometimes occurs that planting 15 to 20 pounds of seed per acre produces a great abundance of plants. These extra plants have to be removed at thinning time. It is probable that such stands should be thinned earlier, before crowding does injury, than the less dense stands which are less affected by crowding. The ideal stand for easy thinning is one where there are relatively few beets so evenly distributed in a row as to allow the desired spacing to be obtained. Single beets are not affected by crowding. They make a prompt and sturdy growth and are easiest to handle in the thinning process. However, a seeding rate that would give such a sparse distribution is likely to produce an uneven stand of beets. It is therefore desirable to use heavier rates of seeding to insure a stand of seedlings in spite of adverse conditions.

SOIL CRUST

Crusting of the soil is one of the very common causes of failure to obtain a good stand of sugar beets. Heavy rains pack the soil and lead to crust formation, especially where the drying is rapid. Some sandy soils do not crust, but all heavy soils are subject to this difficulty. The nature of the beet seedling is such that it is very important to maintain a loose mulch on the field during germination, as the small beet seed does not contain more than enough food reserve for the few days of normal growth necessary to bring the seed leaves above the ground, and the young slender stem which is tipped by the two small cotyledons is not very efficient in breaking through a hardened soil surface. Seedlings that are retarded in their penetration of the soil surface are weakened or killed. The plant stems are bent or curled, and in instances where the cotyledons are near the surface they receive some light which causes them to open prematurely. Such conditions lead to the death of the young plants, with the result of a greatly reduced stand. It is therefore necessary to adopt all possible measures to prevent crust formation or to break the crust after it does form. Many methods are used to prevent and break crusts on the beet fields. Prevention is much better than breaking the crust after it has been formed. Planting in a seed bed with a good mulch is the first essential of prevention. If a storm comes, the land should be harrowed with a light beet harrow as soon as it is dry enough for the use of this implement. Blind cultivation of the rows before the plants have reached the surface is also excellent. Harrowing with a heavy harrow often disturbs the seeds and is not advisable. Rolling breaks the crust, but if the land is wet the roller may pack the subsurface too tightly and damage the crop.

If the seed is planted at too great a depth to permit rapid germination a heavy harrowing is beneficial when done at right angles to the direction of the rows. This should be done before all of the seeds have germinated and when the land is in a friable or dry condition. If a very heavy crust forms on the land, the use of vigorous methods to destroy it is warranted. The corrugated roller is usually the best implement to use.

HANDLING THE GROWING CROP

Since a number of salient points are to be considered in each of the various operations involved, the following items in handling the sugar beet from the seedling stage to maturity are discussed in detail. Great emphasis is placed on the importance of obtaining first-class hand labor to perform in a proper manner the blocking or spacing of the beet plants, the selection and retention of the strongest and healthiest plant, and the thorough and careful hoeing of weeds from the beet row.

SPACING

The number of sugar beets to grow per acre varies somewhat for different areas and different fields. The present accepted standard is 26,136 beets per acre, which is the computed number of beets in a perfect stand spaced 12 inches apart with 20-inch rows. In the study of a large number of plots it was found that the maximum yield was produced, in the area under consideration, when the beets were spaced approximately 10.3 inches apart in 20-inch rows. Closer spacing to 8.8 inches reduced the yield to 4.3 per cent, or less than 1 ton. In these tests the 10.3-inch spacing produced an average yield of 18.79 tons of beets per acre, compared with yields of 17.99 tons for 8.8-inch spacing, 17.74 tons for 12.3-inch spacing, 15.61 tons for 15.3-inch spacing, 13.11 tons for 20.2-inch spacing, and 9.82 tons for 30-inch spacing. Under normal conditions the increases of yield from growing more than the 12-inch stand are not usually sufficient to more than pay for the increased cost of production, but the losses caused by 15-inch or 20-inch stands are such that they greatly reduce the profits gained from proper sugar-beet growing. The majority of the commercial fields are now producing beets in fields that have from 60 to 80 per cent of a perfect 12-inch stand in 20-inch rows, which are approximately 15-inch and 20-inch stands. It is believed that the majority of growers would be benefited by closer than present spacing.

As the curly-top disease is a factor in much of the area under consideration, the effect of spacing distance is considered with reference to yields in years when curly top is prevalent and in years when the disease does not appear. The number of beets per acre as determined by stand counts and the corresponding plot yields for 1925 and 1926 were compared. In 1925 the beets suffered practically no injury from the curly-top disease. The figures obtained for that year indicate that a spacing closer than 12 inches did not produce a marked increase in yield. In 1926, a year of severe injury from curly top, beets that were closely spaced (8 to 10 inches) produced the best results. Upon comparison of the results obtained in these years it was noted that in 1925 (no curly top), as the spacing between beets increased, the size of root increased, whereas in 1926, under curly-top conditions, the average size of beet remained practically fixed, irrespective of the spacing. In 1925 the range of size of average beets was from 2.85 pounds per beet where less than 10,000 beets were grown per acre to 1.58 pounds average weight of beets where 30,000 beets were grown per acre. In 1926 the average weight of beets for these respective stands was 1.03 and 1.06 pounds. Such data indicate the advisability of closer spacing in curly-top areas.

BLOCKING AND THINNING

Thinning should begin when the beets have 4 leaves and should be rushed along to completion by the time the beets have 8 to 10 leaves. Small beets are easiest to thin and suffer less from crowding than large ones. There is experimental evidence to indicate that early thinning produces better yields than later thinning. This recommendation can be made for those fields in which damping-off, or blackroot, is not a factor. The early thinned plants avoid the detrimental crowding conditions experienced by the plants thinned later. On the other hand, it is practically impossible to be certain that damping-off of seedlings will not develop in sugar-beet fields. The practice which is now coming into favor in the handling of sugar-beet seedlings in the intermountain region, especially in fields where blackroot is a factor, is to delay thinning until there is marked differentiation between the healthy and the diseased beets. Healthy beets in a row are sturdy and have straight petioles, whereas diseased seedlings are backward and have bowed petioles. Thinning should be delayed until the distinction between the sturdy and the weak seedlings is plain.

The thinning and blocking of beets is done in one operation by the use of short-handled hoes or in two operations if long-handled hoes are used. Either method is satisfactory if carefully done. Narrow, sharp hoes are necessary for good thinning. Wide hoes cause unduly wide spacing of the beets, and dull hoes do not cut deep enough to kill all weeds and all the beet plants that should be removed. As a rule, the use of the short hoe is quicker but is conducive to poorer work.

The purpose of blocking is to remove quickly and easily the surplus beets between the tufts of beets from which the best individual is to be selected, since only one beet should be left in a place. Where blocking and thinning are done as two separate operations, excellent results are obtainable because each operator has but a single task to perform.

The best results in handling the stand of seedlings will be obtained if the following method is closely followed: In this work one laborer blocks the beets and another thins to a single plant. This blocking requires two strokes of the hoe for each beet left. The first stroke is made to block out a tuft of beets 3 to 4 inches long, and the second stroke reduces the number of beets left in the tuft. Satisfactory work requires that the first stroke be made to mark out the tuft in the row, and the second is made merely to reduce the size of the tuft by a cut to the rear of the cut made by the first stroke. This method, which laborers quickly learn to perform, gives more even spacing and results in a better final stand than the common method where the first stroke marks out a tuft of beets and the second stroke merely widens the first spacing. Unless the former method is used and careful supervision of the operation given, careless laborers will block out two full widths of the hoe or more (12 to 15 inches) preliminary to thinning to a single beet. The small tuft of beets remaining after the blocking operation is thinned by hand to one beet. As has been explained, the largest and healthiest seedlings should be left. In actual tests, selection of the large, healthy seedlings has produced yields several tons per acre greater than were obtained by leaving the smallest beets. The practice of removing the seedlings most con-

veniently pulled instead of making careful selection to leave only the sturdy, healthy beets is entirely too common.

Since poor work may reduce the yield of beets by 3 to 5 tons per acre, the grower can well afford to supervise closely the workers who are blocking and thinning beets to see that superior work is done. Uniformity of size and stand make for a more complete utilization of all parts of the field, and therefore are desirable fac



FIGURE 8.—A group of sugar beets in actual position as they grew in the row, showing the variation in size of the plants and the proper depth of cutting out surplus beets. Note bowed petioles of certain individuals; these are diseased

tors in the growing of sugar beets. Any practice which destroys the stand usually decreases the yield. It is therefore imperative for the grower to acquaint himself with the best thinning practice and to supervise his laborers so as to conform to the following instructions:

Leave the largest and healthiest plants, one in a place at intervals of 10 or 12 inches.¹ (Figs. 8 and 9.) With seedlings of fair size, the characteristic straight petioles serve to identify the healthy individuals.

¹ The closer interval would seem preferable in a curly-top year.

Make the first stroke to space the tuft and the second to reduce the number of beets in the tuft.

Hoe crosswise of the row, cutting just deep enough to kill all weeds and surplus beets.

Drag as little as possible of the dirt away from the row.

Leave the beets standing as erect as possible and the roots covered with loose dirt.

MECHANICAL BLOCKING OF BEETS

The question often arises whether it is possible to block beets mechanically. In good stands of sugar beets it is possible to use a

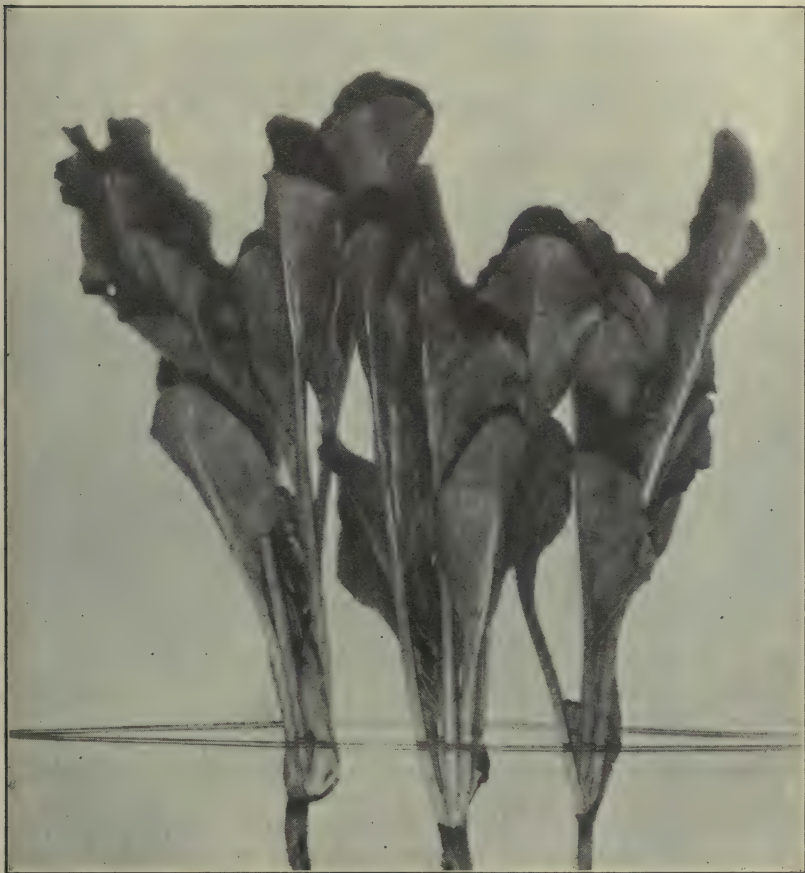


FIGURE 9.—The three largest beets of the group in Figure 8. Compare these with some of the smaller beets in the same group. The largest and healthiest seedling of a group should be left when thinning

beet cultivator to block the beets partially, but poor and uneven stands can not be so handled. Mechanical blocking saves a part of the labor usually necessary to block and thin the crop. It is especially advisable where thinning is to be delayed, as the early blocking with a cultivator diminishes the deleterious effect of crowding. Some single beets are properly spaced and thinned and have the advantage of early thinning. In weedy fields the cross-cultivation resulting from mechanical blocking is very beneficial.

Mechanical blocking can be done with the knives commonly used on the sugar-beet cultivator. A knife should be set to cut the space covered by each wheel of the cultivator. It is advisable to turn the blades of the end knives inward. When used without a shield of some sort, duckfeet are not so efficient as knives, as they cover more of the remaining beets. Some growers use the disk cutter as a suitable shield. This cutter makes a clean cut without disturbing the block of beets. Irrespective of type of tool used, the cultivator should be fitted with a marker to enable the operator to make even-width guess rows. In spacing the tools used on the cultivator bar they must be varied with the stand of beets. In case duckfeet and disks are used, these tools must be staggered on the tool bar by placing the disks on the front tool bar (if there are two tool bars on the cultivator) and the duckfeet directly behind. For the purpose of illustrating the practice, knives will be used as an example;



FIGURE 10.—Sugar beets mechanically blocked by cross-cultivation as a labor-saving operation: A, Part of the field which was mechanically blocked; B, the original stand of beets. The blocking was done with a cultivator having 6-inch knives 10 inches apart, thereby leaving an average final stand of 108 beets per 100 feet of row

6-inch to 8-inch knives may be used. The use of 10-inch knives in mechanical blocking, set 12 inches apart so as to leave a 2-inch tuft of beets, does not seem practicable since very few stands of beets are even and thick enough to permit of this type of close blocking. It is preferable to use 8-inch knives set 12 inches apart or 6-inch knives set 10 inches apart to leave 4-inch tufts of beets. The latter method was used in an experimental field in 1927, an average of 108 beets being left to 100 feet of row. (Fig. 10.) The method presents many possibilities with fields of good initial stand; and it should be tried in comparison with the ordinary methods.

HOEING

Careful work during thinning operations will greatly reduce the amount of hoeing necessary later on. Where due diligence is exercised during thinning by thorough hoeing, the space between and

around the beet plants will not only destroy all weed growth but will greatly assist in creating an effective soil mulch.

The first hoeing of beets is usually done in a week or 10 days after thinning, and a later hoeing is performed when large weeds appear in the fields. Ordinarily two hoeings are sufficient for the average field, but weedy fields often require more attention. In the case of the second hoeing when performed later in the season, it is a much better practice to pull the weeds by hand than to hoe them. Weeds should generally be pulled immediately following irrigation. The use of a hoe at this stage of crop development usually causes more harm than good, since the beet leaves cover the rows to such an extent that the laborer can not see where the hoe strikes. Such a blind operation may result in many of the beets being cut. It is a far better practice to pull all such later weed growth by hand where reasonably good work has been done in the earlier hoeing. The use of a hoe tends to fill the irrigation ditches, which often necessitates refurrowing the field for further irrigation.

CULTIVATION

Sugar beets require five or more cultivations during the season. At least one of these should be performed before thinning, another within a day or two after thinning, and others later at intervals until the leaves cover the rows. A close deep cultivation soon after the beets are thinned prevents a drying out of the roots and hastens growth. This can be done most easily in the early morning when the plants are standing erect. Cultivations can be made after the leaves cover the rows, if done in midday when beets are somewhat wilted. Too many leaves are broken if the beets are cultivated when the leaves are turgid. Small beets may be cultivated most easily early in the day when they are most erect.

Cultivation serves to kill weeds, conserves moisture, loosens and aerates the soil, and improves the condition of the soil. All these factors have the net result of benefiting the crop. Weeds are most easily killed when small, therefore early cultivation should be frequent and effective. When a mulch has been established, the weeds killed, and the ground loosened to a depth of approximately 3 inches, there is no further need of frequent tillage if the land remains in this excellent condition. Further tillage is necessary only as storms occur and form crusts, or as small weeds appear.

While close deep cultivations are essential in the early development of the beet plant, care must be exercised to so set the cultivator tools for later cultivations that the lateral roots are not injured.

Different tools are used for the various cultivations. (Fig. 11.) The first cultivation should be done with the knives or disks set close to the row and a duckfoot cultivator run deep in the middle of the rows. If the land is crusted or littered with trash, the disks operate more efficiently than the knives. On such land it is sometimes necessary to use the duckfoot in the center of the row as a separate operation from the use of the knives or disks, but on most lands the complete equipment can be used in one operation. The knife-edged bulltongues are used for the cultivations when a deep mulch is desired. Three of these are used between each pair of rows,

with the middle one set deeper than the others. This is a new type of equipment and is not so commonly used as duckfeet, knives, and deertongues. Large or small ditchers are used for making irrigating furrows, the choice of these depending upon the type of soil. The ditches are not difficult to make in fields that are properly cultivated. When irrigating before the leaves cover the ground, it is advisable to cultivate as soon as the land is dry and reditch for future irrigations.

Early cultivation conserves moisture, maintains the mulch, and kills the weeds when they are small and easily destroyed. These first cultivations are usually done with a cultivator equipped with knives or disks. Disks are good for cultivating close to the beets, but often leave the plants on a narrow ridge where they are in danger of injury from drying. It is a good plan to use duckfeet along with the disks or knives. (Figs. 12, 13, and 14.) If the duck-

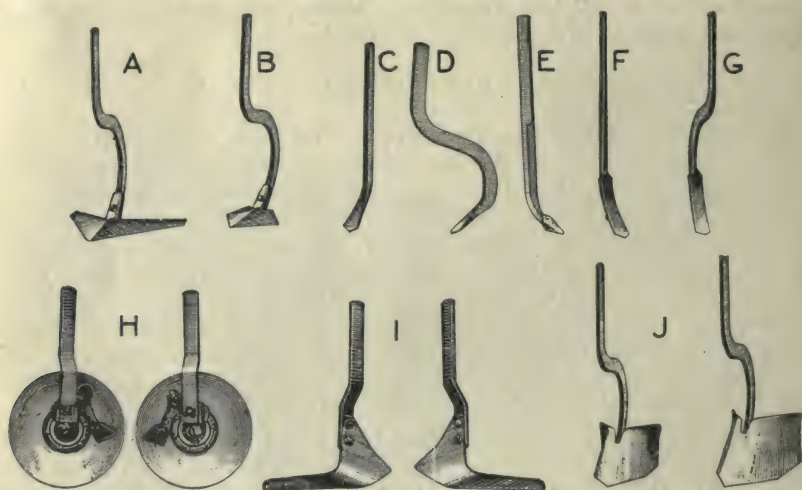


FIGURE 11.—Beet-cultivator tools; A, Large duckfoot; B, small duckfoot; C, straight-shank calftongue; D, curved-shank calftongue; E, knife-edged calftongue; F and G, diamond-point shovels or bulltongues; H, disks; I, knives; J, irrigating shovels, small and large

feet are set deep and the soil is in a loose, friable condition, they do not cover the beets. Close cultivation with knives covers more plants but does not throw the dirt away from the row as much as the disks. The proper adjustment of the cultivator tools is very important and must be varied to suit the individual fields. Four-row cultivators are adjustable so that the tools can be correctly spaced to fit four beet rows as planted by the drill. Tools when set on the heel or set flat do not penetrate as well as those set to run on the point. Duckfeet if nosed down too much throw dirt on the rows. The levers on the cultivator are easiest to operate when the tools are set to dig into the soil. Loose, swinging neck yokes or harness cause the cultivator to follow the beet row irregularly.

HARVESTING

The beginning of the sugar-beet harvest is determined by the purchasing company's announcement of readiness to receive the beets.

This date is governed by the ripeness of the crop as determined by field samplings. After permission to harvest is granted, the grower may begin immediately or may delay handling the beets until later



FIGURE 12.—Cultivation of sugar beets with disks only. The field is left uneven

in the season. There are advantages in both early and late harvesting. If the beets are in a growing condition the yield increases until such time as the conditions become unfavorable for growth. On the other hand, there is some danger of unfavorable weather conditions that stop the growth and make the harvest difficult.



FIGURE 13.—Cultivator equipped with disks and duckfeet. The field is left in better condition than the one shown in Figure 12

Freezing does not often destroy the beets, but snow and freezes make harvesting more expensive. Early harvesting permits more fall plowing and other work in preparation for the crop of the follow-

ing year. Beet-harvest time is one of the busiest seasons of the year, and it is more profitable to harvest in an orderly manner with the size of crew that completes harvesting the crop before there is loss from storms.

Beets are lifted by a double-pointed puller which lifts and loosens them from the soil. The proper adjustment of the beet puller is very important. A poorly adjusted puller leaves a portion of the beets in the ground or breaks off the roots. These losses sometimes amount to a ton or more of beets per acre. Old and worn puller points often cause a puller to tilt behind and break off the roots of many of the beets.

Careful topping is very essential. The beets should be topped in a manner that meets the requirements of the receiving company. It is usually specified in the grower's contract that the beets shall be topped at right angles to the long axis of the beet and at a point indicated by the lowest leaf scar. To top lower than this reduces the tonnage. To top higher than this is useless, as the receiving company samples and tares the beets and deducts from the weight an amount estimated to be the excess crowns left on the beets.

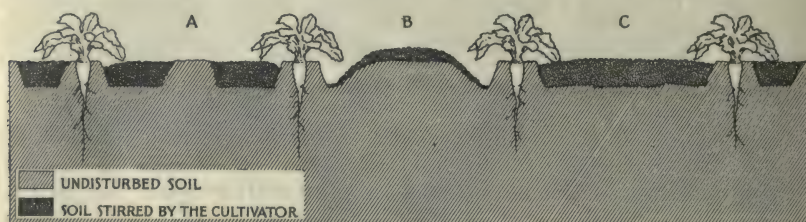


FIGURE 14.—Diagram illustrating results obtained with a cultivator equipped with various types of tools: A, Cultivation with knives; B, cultivation with disks; C, cultivation with knives and duckfeet—the best method of cultivation

In some areas the toppers pile the beets and top them from the piles. The piling reduces the dirt tare, as the double handling shakes more of the dirt from the roots. In other areas the toppers use a knife with a hook attached to the point and top the beets from the row at one operation. The hooks on the knives permit of more rapid topping, but are objected to in some areas since the wounds caused by the hooks are often the starting point for storage rots. A smooth spot should be prepared for piling the beets in the field. In this manner the beets are easier to load and less dirt is thrown into the wagon and hauled to and from the receiving station.

Dirt returned to the grower at the receiving station should not be dumped in the field because of the danger of introducing nematodes in this way. The machinery of the receiving station can not be cleaned sufficiently to prevent a slight carry-over of dirt from one load to another, and many cases of field infestation with nematodes are traceable to the dirt brought back to the field from the sugar-beet dump.

Beets should be hauled immediately after digging, unless they are sufficiently covered with tops or soil to prevent drying or freezing. The loss in weight of beets left in the field after being topped varies greatly with different weather conditions. In one instance beets left in the field for 72 hours after harvest lost less weight

than beets left in the field 17.5 hours. In the first instance there was a period of rainy and cloudy weather, while in the second the weather was very dry and windy. Another experiment indicated that there is some loss where beets are left in the field only a few hours. The loss from small piles is sometimes over 5 per cent of the weight of the crop in 24 hours, and the loss from three days of exposure in small piles amounted to over 20 per cent. Covering a large pile with tops saved nearly 10 per cent of the total weight when beets were left in the field for two days. Beets left in the field for a long period of time and covered with tops lost less weight than those exposed, but neither method of field storage was satisfactory. It is general experience that large piles lose less weight than small piles. Therefore, if immediate delivery of topped beets is impossible, the heavy shrinkage losses can be greatly reduced by making fewer large piles instead of numerous small ones. In any case, the piles of freshly topped beets should be covered with a liberal quantity of beet tops.

For many years there has been a continuous attempt to perfect several types of machines designed for harvesting and topping the beets by one mechanical operation. At present there are none in common use. Recent improvements in design of such machinery indicate that the outlook is encouraging for development of practicable mechanical means of beet harvesting.

SUGAR-BEET BY-PRODUCTS

BEET TOPS

In harvesting sugar beets the crown and the tops are removed from the root and discarded. These are usually dropped in the field until after the harvest is completed. In most beet-growing areas the tops are fed by simply pasturing stock in the fields. This method has been found to be satisfactory in the irrigated areas. The average feed value of 1 acre of beet tops is approximately the same as the feed value of 1 ton of alfalfa hay. Such an estimate of the value of an acre of beet tops is somewhat indefinite, but it gives a good method of estimation by the comparison with a common stock feed of the area. (Table 1.) From 3 to 8 tons of green tops are produced from an acre of beets.

TABLE 1.—Percentage composition of by-products of sugar beets¹

By-product	Water	Solids	Ash (total)	Protein (N × 6.25)	Reducing sub- stances (direct as invert sugar)	Apparent sucrose (reduc- ing sugar method)	Nitrogen- free extract (includ- ing sugars)	Fat (crude ether extract)	Crude fiber	Total apparent sugars (sucrose plus invert)
Fresh tops.....	74.80	25.20	6.36	4.03	0.84	3.18	11.81	0.26	2.73	4.02
Top silage.....	66.82	33.18	13.96	3.73	.79	.24	11.28	.44	3.78	1.03
Wet green pulp.....	90.99	9.01	.38	.90	.02	.04	5.73	.05	1.95	.06
Dried pulp.....	7.48	92.52	4.41	9.76	.25	.52	56.95	.52	20.88	.77
Pulp silage.....	90.48	9.52	.61	1.38	(²)	(²)	3.95	.18	3.40	(²)

¹ Compiled from United States Department of Agriculture Circular 319, Composition of Sugar-Beet Pulp and Tops and of Silage Therefrom.

² Trace.

Some growers allow the tops to become wilted and then pile them in small piles for further curing, and either pasture the cured tops or haul them to the feed racks. This method involves more labor, but a greater feed value is obtained. Another method is to put the tops into a silo or pit where they are mixed with an equal amount of straw. This involves the expenditure of more labor than pasturing. Siloing has been found to be profitable where the silage was properly made and there was not too much dirt adhering to the tops. Some unfavorable results have been obtained by feeding beet-top silage that contained too much dirt. Moist and wet tops carry more dirt than dry ones. Methods have been proposed for washing dirt from tops to be siloed or fed in the feed racks, but such practice is not in common use.

Green beet tops are succulent, and stock should have additional concentrated feed in the ration. Beet tops when fed to dairy cows in large quantities may impart a disagreeable flavor to the milk. This may be overcome in part by feeding the tops following milking.

A small quantity of fresh beet tops does not injure horses or mules, but feeding moldy or spoiled tops or silage is unsafe. The tops should be more generally utilized for cattle and sheep feeding. The succulent ration of green or siloed beet tops is of special value in feeding, as it is available at a time of year when there is a scarcity of other succulent feeds. Beet tops are sometimes plowed under for their benefit to the soil. In most instances it is more profitable to pasture or feed them and return the manure to the soil.

BEET PULP

Beet pulp is a by-product that remains after the beet roots have been sliced and the sugar extracted. Most of the sugar manufacturers sell this by-product to the livestock feeders in the vicinity of the factory at a low cost. The pulp is an excellent stock feed and may be fed in the fresh, dried, siloed, or pressed form. The greater portion of the pulp in the irrigated area is conserved in silos, but many factories are now pressing and drying the pulp. Analyses of pulp are given in Table 1. Green pulp and siloed pulp are commonly fed to feeder stock, while dried pulp is often fed to dairy cows. Dried pulp has the advantage of being a more concentrated feed than cured or pressed pulp. It is more easily kept and stored for long periods and does not have an odor that is imparted to the milk. Pulp is most profitably fed when more concentrated feeds are added to the ration.

MOLASSES

Molasses from the beet-sugar mills makes a good stock feed when added to other feeds, such as pulp, beet tops, hay, or grain. It contains about 50 per cent of digestible carbohydrates and has a high feeding value when fed in a ration. The most common use of beet molasses is to feed it mixed with ground alfalfa hay or beet pulp. Beet molasses contains approximately 5 per cent of potash salts and can not be fed in large quantities to any stock. From 3 to 5 pounds per 1,000 pounds of live weight may be fed daily.

LIME

Waste lime has not been made use of by the beet-sugar factories of the irrigated areas except in a few isolated instances. At most factories it is sluiced into settling basins or streams and not used. The soils of the area are not lacking in lime, and very few growers have found that the addition of lime to the soil was of any marked benefit. Near some factories there have been found low areas, which were filled with the waste lime combined with waste water from beet washings and from the Steffins houses. This practice has reclaimed some valueless lands, and in several instances excellent beet fields have been built up. In the humid areas of the United States and in Europe more use has been found for the waste lime. Fresh waste lime contains approximately 0.3 per cent nitrogen, 0.5 per cent phosphoric acid, 0.2 per cent potash, 81 per cent calcium carbonate, and about 13 per cent organic matter, all of which have some value for some types of soil.

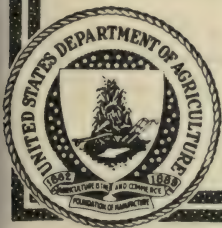
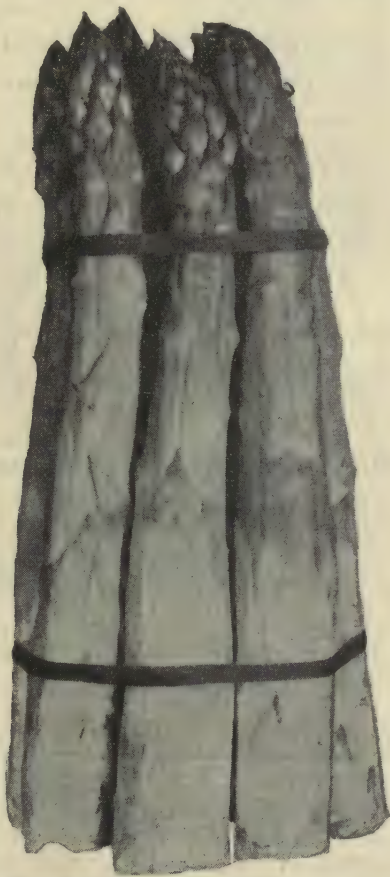
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U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1646

ASPARAGUS CULTURE



ASPARAGUS is an important truck crop, both as a fresh vegetable and for canning purposes.

It can be grown under a wide range of soil and climatic conditions, but is not well adapted to some localities in the South where the winters are not severe enough to check the growth and give the plant a dormant period.

Vigorous 1-year-old crowns produce the heaviest yielding plantations. Crowns more than 2 years old should not be used for planting.

A well-cared-for plantation may yield profitable crops for a period of from 15 to 20 years, but it is generally desirable to renew the beds after 8 to 10 years.

In localities where asparagus rust is prevalent, only varieties resistant to the disease should be used for starting a new plantation.

This bulletin is a revision of and supersedes Farmers' Bulletin 829, Asparagus.

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ASPARAGUS CULTURE

By ROSS C. THOMPSON, associate horticulturist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry

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IMPORTANCE OF THE INDUSTRY

ASPARAGUS is one of the most valuable of the early vegetables and perhaps the most important of the perennial vegetable crops. It is healthful and palatable, both as a fresh vegetable and as a canned product. Its importance as a market garden, truck, and canning crop is growing, as evidenced by the rapidly increasing acreage being devoted to its production, both for fresh consumption and for canning purposes.

The acreage devoted to the production of asparagus, according to the Bureau of Agricultural Economics of the United States Department of Agriculture, increased from 65,530 acres in 1925 to 109,810 acres in 1935. Almost half of the crop is used for canning, and the rest is grown to be consumed fresh.

The States leading in the production of asparagus to be consumed fresh are California, New Jersey, South Carolina, Georgia, Illinois, Maryland, and Washington. Approximately one-half of the asparagus consumed in the fresh state is produced in California. The growing of asparagus for canning purposes is localized almost wholly in the Sacramento and San Joaquin Valleys of California, a small additional amount being produced in New York.

CLIMATIC AND SOIL REQUIREMENTS

Asparagus is cultivated to some extent in nearly all sections of the country. In many places it is found growing wild where the seed has been disseminated by wind, water, birds, and other carriers. Conditions suitable for commercial production are much more limited.

The asparagus plant (*Asparagus officinalis*) is a native of temperate regions and is best adapted to localities where low temperatures

prevail during some period of the year. For normal development it is necessary for the plant to have periodic intervals of dormancy. During the growing season, after cutting has stopped, the plant stores up reserve food materials in the roots. During the dormant period important chemical changes take place in the reserve food supply that greatly influence the future development of the plant. Without such periods the plant does not develop properly, and the shoots may become less vigorous and more spindling each year. Asparagus culture on a large scale should not be undertaken where climatic conditions are such that the plant continues to grow throughout the year without a dormant period.

Asparagus can be grown on many kinds of soil, but good drainage is essential. The best types of soil for permanent plantations are deep, loose, and light, such as mucks and light sandy loams. The asparagus plant has an extensive root system and for maximum development must have an open, porous soil. Since early spring growth depends on the reserve food stored in the fleshy roots, a soil should be provided that permits unhampered development of the storage roots, which may reach a length of over 10 feet. Where earliness is important, a soil that warms up readily in the spring is essential, for temperature is an important factor in early growth.

Very light sandy or gravelly soils having a porous subsoil should be avoided. The moisture-holding capacity of such soils is too low for profitable asparagus production. Soils having either a gravelly or hardpan subsoil are not desirable. Many of the commercial asparagus soils of the South have a light sandy topsoil underlain with clay. Heavy soils, while not the best, may be satisfactory for asparagus, if they are not so heavy that they bake. Muck and light sandy loams well supplied with organic matter are ideal for asparagus.

Asparagus is found growing naturally on the banks of streams and near salt marshes, where the salt content of the soil is high and the reaction somewhat alkaline. It does well in moist places, if the water table does not come within 4 feet of the surface.

Asparagus will thrive in soils having a salt content too high for many other crop plants but will not tolerate extreme acidity. Soils ranging from slightly acid to slightly alkaline are best for asparagus. Land known to be very acid should be given an application of lime to bring the reaction to near neutral before being planted to asparagus.

Although the tolerance of the asparagus plant to various salts makes it possible to utilize for its production land that is too alkaline for the growing of certain other crops, the yields are likely to be lower and the life of the planting shorter on such land than on land more nearly neutral in reaction.

FERTILIZING BEFORE PLANTING

The long time that the land is occupied by an asparagus plantation makes it highly desirable that the soil be made fertile and that it be put into the best physical condition possible before the plants are set.

The question of fertilizer practice is a local problem and to a large extent must be determined by local conditions. What has proved to be a good practice in one locality may not be the best procedure in some other where soil and climatic conditions are different. It should be borne in mind that a fertilizer that gives the greatest yield may not return the greatest profit per acre, for the cost of the fertilizer may be proportionately more than the increase in yield over that with another treatment.

Asparagus thrives best in a soil well supplied with humus. In soils of mineral origin low in organic matter the application of some organic material may be of more importance than the addition of nitrogen, phosphorus, and potassium. Soils of organic origin, like peat and muck, are already well supplied with humus and may need only the addition of one or more of the fertilizing elements to put them in a good state of fertility.

Where organic matter is needed it can best be supplied in the form of animal manure, if it can be obtained at a reasonable cost. Such manures are especially desirable in that they add some plant food and also improve the physical condition of the soil by the addition of humus. The present cost of animal manure makes it inadvisable to try to maintain fertility on large plantations by the use of it alone. On the other hand, animal or green manures can not be entirely replaced by commercial fertilizer, unless the soil is already well supplied with organic matter. It is a good practice to supply part of the required materials in the form of manure and part by commercial fertilizer.

Where animal manure is not available, the required organic material can be supplied by turning under a green crop. Some of the leguminous crops, such as cowpeas, soybeans, vetch, or clover, are preferable, as they add some nitrogen to the soil when they are properly inoculated with the nitrogen-fixing bacteria. Where it is impracticable to grow a legume, one of the small-grain crops like rye, wheat, oats, or barley can be used. While the grains do not add nitrogen to the soil as do the legumes, they furnish a large amount of organic material and should be used where legumes cannot be grown to advantage.

In turning under any green-manure crop it is essential that it be done while the crop is still green and succulent. This is especially important in the case of nonlegume green-manure crops. Much of the benefit to be derived from the crop is lost if it is allowed to become too mature before being turned under. Mature plant material requires more time to decay and may interfere temporarily with the soil-moisture supply which is needed by the asparagus plants. Moreover, too heavy an application of mature plant material may result in a temporary reduction in the available nitrates in the soil.

Where a heavy application of animal or green manure is to be added to the soil it should be turned under the season preceding the setting of the asparagus crowns. A light application of well-decomposed manure may be broadcast and worked into the surface soil. If only a limited supply of manure is available, it can be utilized more economically by being placed in the bottom of the planting furrow than by being broadcast. When thus applied, it should be

well rotted and thoroughly incorporated in the soil before the crowns are set.

In addition to manure, an application of commercial fertilizer is usually advisable. In general, the longer the land has been in cultivation the greater is the need for one or more of the fertilizing elements. Soils in the eastern part of the country are more likely to require commercial fertilizer than the western soils. An application of 1,000 to 1,500 pounds to the acre of a complete fertilizer containing 4 to 5 percent of nitrogen, 8 to 10 percent of phosphoric acid, and 6 to 10 percent of potash can often be used profitably. If applied before the plants are set, it should be broadcast and thoroughly mixed with the soil. The application of the commercial fertilizer may be delayed until after the crowns are set. It is applied along the rows and worked into the soil by cultivation.

If a legume rather than a nonlegume is turned under as a green-manure crop, less nitrogen will be required in the commercial fertilizer. Animal manures vary greatly in the percentage of the fertilizing elements they carry. Furthermore, soil origin and climatic conditions influence soil fertility and fertilizer requirements. Such variable factors as these preclude the establishing of a fertilizer practice which would be best under all conditions.

MAINTAINING FERTILITY

Once a plantation has been established, it should be fertilized every year, but the best time to apply fertilizer to an asparagus bed is a debatable question. The first season or two after setting, 1,000 to 1,500 pounds of a complete fertilizer should be broadcast and worked into the soil as early as the soil can be worked, followed by one or two applications of nitrate of soda applied along the rows at the rate of 150 to 200 pounds per acre.

When the plantation has been established long enough so that spears are beginning to be harvested, most of the fertilizer is usually applied just after the cutting season. Asparagus draws most heavily upon the plant food when it is making top growth and storing reserve food in the fleshy roots. Investigations made by the New Jersey Agricultural Experiment Station show that the asparagus plant can utilize nitrates in the spring and during the cutting season. The records of yields for 9 years at the Maryland Agricultural Experiment Station showed no consistent difference in the yield of asparagus fertilized at the beginning and that fertilized at the end of each cutting season. Some successful growers apply quick-acting nitrogen fertilizer early in the spring and side dress the rows during the harvesting season, believing that early applications of such nitrates help to maintain production and quality, especially where green asparagus is grown. It is, however, generally considered a better practice to delay the application of most of the fertilizer until after the cutting season, when the plant can use the fertilizer most efficiently.

Where animal manure is available it is a good practice to broadcast at the end of the cutting season as heavy an application as is economical. This should be supplemented with a complete fertilizer containing from 4 to 5 percent of nitrogen, 6 to 10 percent of phos-

phoric acid, and 6 to 10 percent of potash applied at the rate of from 1,000 to 1,800 pounds per acre. Many eastern growers are using 4-8-6 and 4-8-7 fertilizers with good results.

The use of common salt or sodium chloride was at one time considered essential for asparagus production. It has been shown that the sodium salts, sodium chloride and sodium carbonate, may be beneficial on soils low in potassium. Where the potassium content is high or where fertilizers relatively high in potassium are applied, the addition of sodium salts has produced little response. The stimulation obtained from sodium salts can no doubt be more efficiently obtained by the use of potassium. The best growers obtain satisfactory yields without sodium salts, and their use is not generally advisable.

In some of the eastern asparagus sections cowpeas and soybeans are being grown as a late cover crop with good results (fig. 1).



FIGURE 1.—Soybeans grown as a cover crop following the cutting season.

The seed of the cover crop is drilled in between the asparagus rows about 3 weeks after the cutting season, about 5 pecks of seed being used to the acre. The cover crop tends to prevent weed growth and, if the growth is disked in, adds considerable organic matter as well as some nitrogen to the soil. This is a good practice and one likely to become more general with the increasing scarcity of animal manure.

VARIETIES

There are only a few varieties of asparagus, and the varietal differences between some of these are not well defined. The constant mixing of strains in the field, which is due to the male and female flowers being borne on different plants, makes it difficult to obtain

seed that will produce plants uniform in type and true to varietal characteristics. Since the crowns are propagated almost wholly from seed, wide variation is likely to appear in any lot of crowns unless special effort is made to isolate the seed-producing and pollen-producing plants. Where more than one variety is grown for seed, careless handling of seed stocks soon results in mixture and in varietal differences becoming less distinct.

Because of these facts and the fact that the bed or field to be planted will last for many years, the importance of care in selecting planting stock is apparent.

The two general types of asparagus are based on the color of the spears. The less important group includes such varieties as Conover Colossal and Mammoth White, which produce light-green or whitish spears. The spears of this group are violet or reddish colored before they are exposed to the light and become light green in full light. The more important group includes such varieties as Palmetto, Argenteuil, and Mary Washington. The tips of the spears before exposure to the light are purplish and the spears become dark green in sunlight.

The present list of desirable varieties includes Palmetto, Reading Giant, Argenteuil, Mary Washington, and Martha Washington.

Palmetto is probably the best and most widely planted of the older varieties. It is very similar to Argenteuil. Good strains of Palmetto are somewhat resistant to asparagus rust and are generally productive.

Reading Giant is an old English variety still grown in some parts of the East, especially in New England.

The older varieties are being rapidly replaced by the newer rust-resistant Washington strains. The best and most widely planted of these are Mary Washington and Martha Washington. These strains are the result of years of breeding and selection work done by the United States Department of Agriculture in cooperation with the Massachusetts Agricultural Experiment Station and other co-operators throughout the country, for the purpose of obtaining varieties resistant to asparagus rust (*Puccinia asparagi*). Of the many varieties and strains obtained from all parts of the world for this work and grown at Concord, Mass., not a single plant was found to be completely immune to the disease. However, in 1910 a vigorous rust-resistant male plant was isolated from a lot of New American, of unknown origin, which, with a resistant female plant from Reading Giant, procured from Sutton & Sons, Reading, England, gave the progeny from which the first Washington strain was selected. Other rust-resistant female plants were later isolated and used in the crosses, from the progeny of which the present Washington rust-resistant strains were selected. These strains are now the most rust resistant of the varieties in cultivation.

Aside from their rust resistance, the Washington strains are of high commercial quality, fully equal to or superior to the best varieties on the market in earliness, vigor of growth, and size and quality of shoot. They are also more uniform in size, shape, and color than the old standard varieties and are very productive of large spears. These strains have already replaced the older varieties

in many asparagus sections and are the more desirable even in sections not subject to rust epidemics. The Martha and Mary strains are very similar, and although the former is more rust resistant, the latter strain is slightly earlier and more vigorous and is resistant enough for practical purposes. It is the more popular and the better for general planting in most asparagus sections.

The demand for seed and roots of these strains, especially of the Mary Washington, for a long time exceeded the supply. Their development and distribution had a marked effect on the asparagus industry. The greatly increased acreages of asparagus planted throughout sections of New Jersey, South Carolina, Georgia, and California during recent years have included a considerable and increasing percentage of these strains.

A number of older varieties have not been mentioned, since most of them are less desirable than the newer strains. In fact, many nurserymen and plant growers now list only the varieties resistant to asparagus rust. In establishing a new plantation it is important to use one of the rust-resistant strains, especially in localities subject to rust epidemics.

GROWING AND HANDLING THE CROWNS

For the home garden or a small planting it is perhaps best to purchase 1-year-old crowns from a reliable nurseryman or plant grower, but where a large acreage is to be planted it may be advisable for the grower to raise his own plants. There are several advantages in growing the crowns rather than in purchasing them, namely, (1) the grower can select his own source of seed; (2) it usually costs less to grow large quantities of crowns than to buy them; (3) special care can be exercised to produce large healthy crowns; (4) selection can be practiced and only the best crowns transplanted; (5) the crowns can be transplanted with less injury from exposure and drying.

The first essential in growing crowns is to obtain good seed of the desired variety. The crossing that occurs in the field, as already mentioned, adds greatly to the difficulty of procuring seed of known quality for planting. Unless special care is exercised in the selection and handling of the seed-bearing and pollen-bearing plants the young seedlings may be somewhat variable. Most asparagus varieties are rather variable at best; hence the importance of good seed of known quality cannot be too strongly emphasized.

Seed capable of producing high-yielding crowns can be obtained only by the selection of high-yielding parents. High-yielding male and female plants should be selected and isolated in such a way that the selected female plants receive pollen only from the selected males and not from other sources. Seed obtained from parents selected and protected in this way should produce crowns capable of a much higher average yield than seed from unprotected field-grown parents. The importance of good seed from high-yielding parents cannot be too strongly emphasized in the case of a perennial crop like asparagus. Even a small difference in yield per crown

resulting from careful selection of seed stock may mean a great deal of difference in profit over the lifetime of the planting.

Close attention must be given the seedbed if good results are to be secured. The soil should be worked until it is free from clods, for germination is likely to be poor in a rough, cloddy soil. A finely pulverized, well-prepared seedbed permits the soil particles to come into close contact with the seed, insuring constant moisture supply and thereby hastening germination.

Asparagus seed is slow to germinate; it often requires from 4 to 6 weeks for the plants to appear above ground, the time required depending on soil temperature, moisture, and depth of covering. Asparagus seed absorbs water slowly at temperatures below 70° F.; hence, if dry seed is planted in cold soil several weeks may be required for the seedlings to appear. Investigations conducted by the California Agricultural Experiment Station show that germination of asparagus seed can be hastened by soaking the seed in water, but seed so treated must be handled properly or more loss than gain may result from the practice. It is recommended that it be soaked at a temperature of 85° to 90° for 4 or 5 days. Little benefit is derived from a temperature below 75°, or from soaking for a short period. After being soaked, the seed must be dried off and planted at once. Damp seed should not be held in containers from which air is excluded, or long enough after being soaked for rots or molds to develop on the seed. For best results, soaked seed should be planted in moist soil; if it is planted in dry soil the benefit of soaking is lost.

In order that the asparagus seedlings may have as long a season as possible in which to develop large crowns, the seeds should be planted as early in the spring as the soil becomes warm enough for germination. The date of planting must be governed by the location and seasonal conditions. In the Imperial Valley of California the seed is often planted the latter part of January or early in February. In the North seeding is frequently done as late as the latter part of May. The best temperature for the germination of asparagus seed is between 75° and 85° F. Below 70° germination is very slow.

If the germination is known to be good it is advisable to plant the seed thinly. It is better to give the plants enough space at seeding time than to attempt to thin them. Thinning is difficult, and the crowns are hard to separate after digging if they are grown so close together that the roots are interwoven. Moreover, thin seeding saves expense and reduces the amount of root injury in separating the crowns.

A good planting practice is to seed in rows 24 to 30 inches apart, allowing 3 or 4 inches between plants in the row. The distance will depend largely upon whether the cultivation is to be done by hand or by horse implements. From 5 to 10 pounds of seed is sufficient for 1 acre.

The depth to plant depends upon the type of soil and moisture conditions. The heavier the soil the shallower the seed should be covered. The chief object in covering seed is to provide proper moisture for germination. The question of uniform moisture during

the germinating period should be borne in mind in determining the proper depth to cover the seed. In light peat soil the seed may have a 3-inch cover; in sandy loam $1\frac{1}{2}$ inches is enough, provided the soil is sufficiently moist for germination.

Weeds should be kept down, as they draw heavily on soil moisture and in dry weather may deprive the asparagus roots of needed moisture. Cultivation should be shallow, especially late in the season, to prevent injury to the developing roots.

Before the crowns are dug, the old tops should be cut and removed so as not to interfere with the digging. A common moldboard plow or a special implement equipped with a U-shaped knife can be used to lift the plants from the nursery row. In digging the crowns care should be exercised to avoid injuring the roots. If the plants are lifted without injuring the tips of the fleshy roots they will continue to elongate after being transplanted. Since the fleshy roots are essential storage organs, it is important that their development be checked as little as possible.

It is best to set the crowns as soon as possible after digging them. Where it is necessary to keep the crowns for a period before setting them out, they should be stored in some dry, protected place at a temperature near 40° F. Extreme drying of the crowns should be avoided. Experiments conducted in California, in which the yields from dried crowns were compared with those from crowns not dried, showed the yields to be greatly reduced by drying. The greatest reduction occurred during the first cutting season, but the injurious effect of drying the roots was apparent the second season.

STARTING THE PLANTATION

In most sections of the country asparagus crowns are set in early spring as soon as the soil can be worked. In some parts of the South and in the Delta and Imperial Valley districts of California, where climatic conditions are favorable, the roots are set late in the fall or during the winter. Fall and winter planting is necessary in some parts of California, as heavy rains interfere with spring planting. Spring planting is preferred in the North because fall-planted roots may be injured by cold before they become established if the winter is severe. The time to plant the crowns must be governed by local climatic conditions.

AGE, SEX, AND SIZE OF CROWNS

One-year-old crowns are the most desirable for setting. In some cases the grower may be justified in planting 2-year-old crowns, but crowns more than 2 years old should never be used. Two-year-old crowns should not be used unless they have been given sufficient space in the nursery row for proper development, and even then the 1-year-old roots are preferable because they result in more productive plantations. Where the crowns are grown very close together, the fleshy roots may be injured in separating the crowns, and severe root injury will materially reduce the yield in years following.

Some attention has been given in recent years to the matter of the relative productivity of male and female plants. Female plants

have been shown to produce larger spears than male plants, but male plants produce a greater number of spears, having a greater total weight than the female. While male plants may be a little more productive than the female, it is doubtful if the grower should make much effort to obtain crowns of one sex for planting. As stated above, 1-year-old crowns are known to be decidedly superior to older crowns, and therefore, since it is impossible to definitely determine the sex in most cases until the second season when flowers and fruits are produced, it seems advisable for the grower to pay particular attention to the selection of large, vigorous 1-year-old roots and leave the matter of sex to chance.

Experimental evidence shows that it is profitable to grade asparagus crowns before planting them, on the basis of size and vigor, and to keep only the largest and best developed roots for planting. All small, weak crowns and those having many small buds should be discarded, as they tend to produce a high percentage of unsalable spears. A desirable crown for planting is one having a large well-developed root system with large buds well distributed over the crown.

PLANTING DISTANCES

The soil must be as thoroughly prepared for asparagus as for any other crop. It should be plowed deep and well worked down. Furrows for the crowns should be opened with a lister or some other suitable implement, the depth to depend upon that to which the crowns are to be finally covered. A deeper furrow is required in a loose soil where the crowns are to be finally covered to a depth of 6 to 8 inches than in a heavy soil where they are to be covered only a few inches.

The distance between the rows depends on whether white or green asparagus is to be grown and on the type of cultivation to be practiced. For a small planting or in the home garden the planting distances need not be so wide as for commercial plantings. Less space between rows is required for growing green asparagus than for growing white asparagus. The latter should have the soil ridged over the crowns so that the spears can attain the desired length before reaching the surface. Where ridging is to be practiced, from 6 to 8 feet should be allowed between rows to provide enough soil to form the ridge. Rows of green asparagus should be from 5 to 6 feet apart. The higher the ridge the more soil required and the greater the space between rows. In some sections green asparagus is cut during the early part of the season, and the white asparagus is harvested from the same beds the latter part of the cutting season. Where the growing of both green and white asparagus is to be practiced the rows should be far enough apart to allow for ridging.

Planting distances vary greatly in different sections and under different soil conditions. Recent investigations indicate that maximum yields of high-quality spears may be obtained when the crowns are set 18 to 30 inches apart in rows 4 to 8 feet apart. Where the rows are close together the distance between plants in the row should be greater. The recommended distances in California are 18 to 24 inches between plants in rows 6 to 8 feet apart. Closer planting is

practiced in some of the eastern sections. In New England the crowns are set 18 to 24 inches apart in rows 4 to 5 feet apart. Too close planting results in a large percentage of small spears. However, very wide spacing may reduce the yield even though the spears are large. Soil fertility and other local conditions must be considered in determining the best planting distances for a given locality.

SETTING THE CROWNS

When the crowns are placed in the furrow, the roots should be well separated and spread in their natural position. It is a good practice to place a small mound of soil in the trench where the crown is to be placed and to set the crown on the peak, allowing the roots to spread out naturally. Although the careful spreading of the roots is a good practice and should be done in small plantings, generally no attempt is made to spread the roots in very large plantings, as it requires considerable time and labor.

At first it is best to cover the crowns with 2 or 3 inches of soil, increasing the depth as the shoots develop, since too deep covering at the time of planting may cause poor growth or the death of many crowns. The extremely deep planting formerly practiced is no longer advised. Deep planting means a late crop, as the soil is slow to warm up to a sufficient depth to promote rapid growth early in the season. In deep loose soils like peat the final depth of the crowns may be as much as 12 inches, but this is too deep for most soils. The final depth of the soil over the crowns should not exceed 6 to 8 inches in light soils and 4 to 6 inches in heavy soils.

CULTIVATION AND CARE

Cultivation should begin soon after the crowns are planted and should continue throughout the season at intervals frequent enough to keep down weeds. Any stirring of the soil should be shallow, as serious injury to the roots may result from deep cultivation, especially after the root system has become extensive and the crowns have grown near the surface. Filling in the furrow during the season will keep down most of the weeds in the row close to the plants the first year after setting, and little handwork may be necessary. After the first season some hand-hoeing is necessary to keep down weeds near the plants. Any working of the soil close to the crowns during the cutting season must be shallow and carefully done to avoid injuring the developing spears. Weed control is very important with a perennial crop like asparagus. A year or two of neglect may result in the soil becoming so foul with seeds that weed control may be difficult and expensive.

If white asparagus is to be grown, the rows must be ridged up, covering the crowns with several inches of soil. Implements of two types used for this purpose are shown in figures 2 and 3. The soil over the crowns must be deep enough for the spears to attain the desired length before reaching the surface. In order to keep the crowns properly covered it may be necessary to renew the ridges every 2 weeks or oftener.

If green asparagus is to be grown, a very low ridge or no ridge at all is necessary. The crown of the asparagus plant increases in thickness thus coming a little nearer the surface each year, so that



FIGURE 2.—A type of asparagus ridger used to a considerable extent in some asparagus-growing regions for renewing the ridges.

slight ridging may be necessary for the growing of green asparagus when the crowns have come very close to the surface. Too shallow covering of the crowns subjects them to excessive heat during hot weather, which causes the tips of the spears to open before they reach the desired length and reduces their market value.

At the end of the cutting season the asparagus beds should be thoroughly cultivated, ridges leveled, and the plantation given flat culture for the remainder of the season. The ridges can be plowed down with a



FIGURE 3.—A very satisfactory homemade type of asparagus ridger.

turning plow or with an implement of the type shown in figure 4. Care must be taken not to disturb the crowns. Any fertilizer to be

applied after cutting should be worked into the soil at this cultivation.

The best way to handle the tops that grow up after the cutting season is a debatable question. Some advocate cutting off the tops as soon as the berries begin to mature and either removing or burning them. It is claimed that delay in removing the tops results in scattering the seed, which may become troublesome upon germination.

In parts of the North where winter temperatures are low it is believed to be advisable to allow the tops to remain in the fall, as they afford some winter protection by holding the snow and pre-

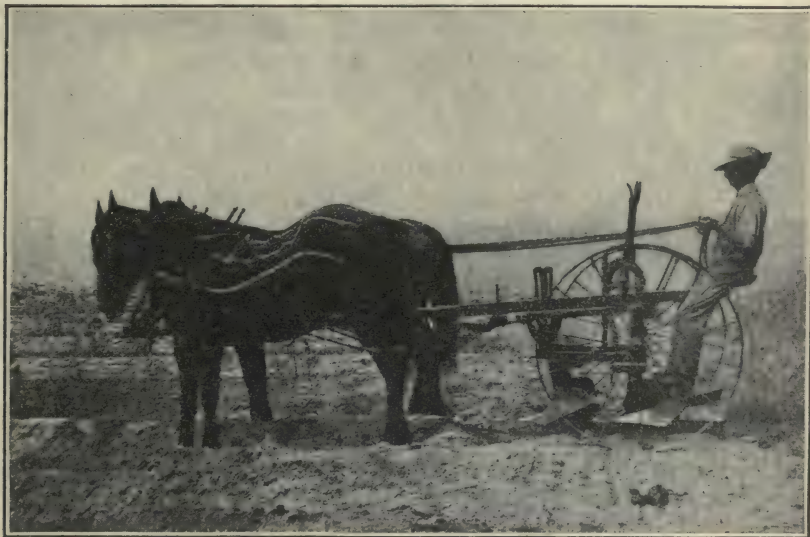


FIGURE 4.—A type of implement used in plowing down asparagus ridges at the end of the cutting season.

venting the blowing of the soil. In this case the tops are disked into the soil in the spring.

Removing the tops too early in the fall is a bad practice. It has been shown that too early removal of the tops stops the transfer of reserve food materials to the fleshy roots. Any decrease in the supply stored in the roots tends to reduce the succeeding crop. For this reason it is desirable to let the tops stand as long as they continue to grow, or until they have been killed by frost. Burning the tops destroys much organic material which might be profitably returned to the soil, provided no serious disease or insect is present; but it has the advantage of destroying diseases and insects that may be present on the stems.

Asparagus stems, being coarse and woody, are difficult to work into the soil. As a general practice it is advisable to collect and burn them.

The grower may feel that he must obtain some income before the asparagus becomes productive. Intercropping is often practiced during the first year or two. Low-growing crops like cabbage, lettuce, beans, and peppers can be grown between the rows without

serious injury to the asparagus. However, most successful growers do not intercrop, and it is not recommended as the best practice. Tall-growing or long-season crops should never be grown with asparagus, as the latter may suffer from shading and depleted soil moisture. When intercropping is practiced, one row between the asparagus rows is sufficient.

LENGTH OF CUTTING SEASON

In many asparagus sections the harvesting of the spears is delayed until the third season after setting. This has been the general practice throughout most of the eastern and middle-western sections, but many growers are now cutting for a short period the second season. In California it is the general practice to cut for a period of 3 or 4 weeks the year following that of planting. It is thought by some that cutting during the year after planting weakens the plants and may reduce the yield in years following. However, many growers who practice harvesting the spears the year following planting are of the opinion that early cutting does not weaken the plants if a good vigorous growth has been made the first year and the cutting period does not exceed 30 days. Moreover, it is their belief that early cutting has the advantage of causing the crowns to spread more widely than they do when no harvesting is done.

The California Agricultural Experiment Station has conducted some investigations on the effect of cutting the spears the first season after setting. The results obtained indicate that the yield and size of the spears are not impaired by harvesting for a short period the year following planting. This is an item of considerable importance, especially to the grower who is pressed for capital. If harvesting can be practiced for even a few weeks during the season following planting without injury to the plants, it will help to defray expenses in bringing the plantation into full production.

Some of the most successful eastern growers are now harvesting spears for a period of 3 to 4 weeks the first season and for 5 to 6 weeks the second season after planting. Subsequently, the beds are harvested the entire cutting period of from 8 to 9 weeks. In California the general practice is similar; after the second cutting season, however, harvesting may extend over a much longer period. The long growing season in California makes it possible to cut over a longer period without injuring the crowns than is possible in sections having a short season.

In planning the management of the plantation it must always be remembered that production depends largely on the care given the bed during the previous season. Early spring growth is made very largely from materials stored in the fleshy roots during the preceding season. In order to have a large reserve supply stored in the roots it is necessary to have a healthy vigorous growth of tops during the summer and fall following the cutting period. A long cutting period may deplete this supply and may impair the vitality of the crowns. Furthermore, cutting too late in the season limits the growth of tops and reduces these reserve materials.

When an asparagus bed declines in production and there is a large proportion of small spears, it frequently means that the food supply has become exhausted. When such a condition develops it

may be beneficial to shorten the cutting season and to give particular attention to fertilization and care during the growing season. However, as the bed grows older, there is always an increasing proportion of small spears, even in highly productive beds.

PROFITABLE PRODUCTIVE PERIOD

The establishment of a new asparagus plantation involves considerable labor and expense; hence adding a few years to the productive life of the bed may be of significant economic importance. If properly cared for, a plantation may be expected to produce profitable yields over a period of 10 to 15 years. On very fertile soil and with special care a bed may remain profitable for 20 years or more.

The plantation can be expected to increase in production for several years following the setting of the crowns. After reaching the peak, profitable yields may continue under favorable conditions up to the twelfth or fifteenth year, when the yield is likely to decline. It is generally desirable to renew the plantation after 10 or 12 years. The new bed should be started 2 or 3 years in advance of plowing up the old one, in order to have it yielding profitably before the old bed is abandoned. On large plantations it may be advisable to renew a part of the field each year until the entire acreage has been replaced by new plantings. It is best not to set the same land to asparagus. If necessity compels its use, it should be planted to some other cultivated crop for a year or two, to rid the soil of the old roots before resetting.

The productive life of the beds depends on climatic conditions, soil texture, soil fertility, planting distances, diseases, insects, and cultural and harvesting methods. While very light soils are ideal for maximum production for several years, the beds are likely to be shorter lived than on heavier soils. The asparagus plant is a heavy feeder; hence profitable production over a long period of years requires heavy fertilization. Continued high production requires that the beds be kept free from disease and insects, for any injury interfering with the proper growth of the tops after the cutting season reduces the quantity of reserve materials stored in the fleshy roots and rhizome. The succeeding crop will be reduced as the reserve food supply is curtailed. Improper cultural practices may interfere with crown development and shorten the life of the bed. When the bed has reached the age where the crowns are near the surface, many of the terminal buds may be injured by cultivation. The injury of the large terminal buds on the crown permits the growth of the smaller lateral buds which produce smaller and often spindling shoots. The injury of the crowns by improper cultivation may be partially responsible for the increase in the number of spindling shoots as the beds become older. Repeated cutting of the tops too early, thereby stopping the manufacture and transfer of food materials from the green tops to the fleshy roots, may reduce the succeeding crops and shorten the profitable life of the plantation.

All these factors and probably many others play a part in limiting the productive life of an asparagus plantation. The grower will be well repaid for special attention to these phases of asparagus culture by increased yields and prolonged life of the beds.

HARVESTING THE CROP

Three kinds of asparagus, classified according to the color of the spears, are marketed. The spears may be entirely green, green with white butts, or entirely white. The greatest market demand is for a green product, whereas most of that grown for canning is white. Nearly all the green asparagus is harvested with a small amount of white on the butt end. The entirely green product that is cut at the surface of the ground does not keep as well as that cut with a portion of the shoot underground. Since the part of the stem that was underground is more woody than the stem above ground, it loses moisture less rapidly than the tender green portion and adds to the keeping quality of the spears.

White asparagus is obtained by growing the spears in darkness. This is accomplished by ridging the soil over the crowns and cutting the shoots below the surface as soon as the tips of the spears appear. White asparagus is grown in some localities where the asparagus beetle is prevalent, in order to reduce the loss from beetle injury. The injury done by the beetle causes the spears to grow crooked, otherwise mars the appearance, and thus destroys their market value. When white asparagus is grown, the beetles have little opportunity to do much damage before the spears are cut.

Asparagus shoots grow very rapidly, especially if the temperature is high. If not harvested regularly, the spears soon become too old. Early in the season the shoots may require cutting only every third day. As the season advances, however, and the growth becomes more active it may be necessary on very light warm soil to cut twice a day.

The cutting should be done with a knife made especially for the purpose. Green asparagus should be 9 to 10 inches in length, and at least half of the length should be above ground. The underground portion should not be too long, as the lower end is fibrous and less palatable. In cutting, care must be exercised to avoid injury to the young spears developing underground. The spears should not be cut too close to the crown, as the undeveloped buds on the rhizome may be injured. Knife injury to buds and unharvested shoots causes them to develop into crooked spears. It is a good practice not to cut closer than 2 inches from the crowns.

The proper way to cut without injuring the developing shoots is to place the knife near the shoot to be cut, forcing it straight down to the desired depth before tilting it to make the cut. The knife should not be forced into the ground at an angle, as many young shoots may be injured in this way. By holding the tip of the spear with one hand the operator can readily tell when the shoot has been severed. Asparagus shoots should not be cut above ground, leaving a stub. Stubs interfere with harvesting and may injure the hand using the knife.

PREPARATION FOR MARKET

Asparagus loses its edible quality very rapidly after it is harvested, owing to chemical changes in the spears which reduce the amount of sugar and increase the amount of tough fibrous material. Analyses of the spears at various intervals after cutting show that the

reduction in sugar content and increase in fiber take place most rapidly during the first 24 hours after harvesting. This is particularly the case in white asparagus. Although deterioration goes on at all temperatures, it is much slower at temperatures near the freezing point. Because of this rapid loss in quality at high temperatures, it is essential that asparagus be brought in from the field, bunched, packed, and placed in a cool atmosphere as soon as possible after it is cut. It is good practice to protect the spears from the sun as much as possible when they are harvested during very warm weather.

If it is necessary to keep asparagus for a time after bunching, the bunches should be stood on end in cold water or on damp moss and held at a low temperature in some place not exposed to air currents. If placed in water and exposed to warm moving air currents the stalks continue to elongate, and changes taking place in the composition of the spears injure their quality. A temperature near freezing reduces these chemical changes to the minimum and preserves the edible qualities of asparagus.

In preparation for market asparagus stalks are generally carefully graded, trimmed, and tied in bunches weighing from 2 to 2½ pounds. Sometimes the poorer grade and field-run asparagus is packed in crates without grading or bunching. In some localities, the Kennewick district of Washington in particular, some first-grade asparagus is shipped loose in crates without bunching. In some sections of the East asparagus is packed in 1-pound bunches, as some markets prefer the small bunch; or the large bunches are divided into smaller ones by the retailer.

GRADES

The Bureau of Agricultural Economics of the United States Department of Agriculture has outlined grades for asparagus, but since these grades are subject to change from time to time anyone desiring the latest detailed information on the subject should write to the Bureau of Agricultural Economics, United States Department of Agriculture, Washington, D. C.

Asparagus may be classified as very small, small, medium, or large, depending upon the diameter of the spears. The following terms are provided for describing the diameter of any lot: Very small, less than one-fourth inch; small, one-fourth to nine-sixteenths inch; medium, nine-sixteenths to three-fourths inch; and large, over three-fourths inch. These measurements must be taken at a point not more than 8½ inches from the tip.

Asparagus may be classified as green if 90 percent of the spears in any lot are of a green color, covering not less than 4½ inches of the length of the stalk. The greenness of the stalks is one of the most important single factors influencing sales in markets that demand a green asparagus.

The grading according to the diameter of the spears depends upon the market demand and the quality of the product. California shippers sometimes pack as many as five grades, based on size. Eastern growers usually do not pack more than two or three grades. After trimming, the bunches should be from 8 to 10 inches long.

BUNCHING AND TYING

White asparagus is usually washed. This is done by placing the spears in wire-bottomed trays or baskets and dousing a few times in a vat of water. Unless a considerable amount of soil adheres to the spears green asparagus should not be washed. If it is necessary to remove soil from the butt end, the spears should be doused in a vat of water, butt down, taking care not to wet the tips. The stalks, butt downward, should be laid on some sloping surface to drain before they are bunched. Asparagus keeps best if it is not wet.

Where asparagus is grown in large quantities for commercial purposes it is essential to have a contrivance for holding the stalks while they are being bunched and tied. There are various devices on the

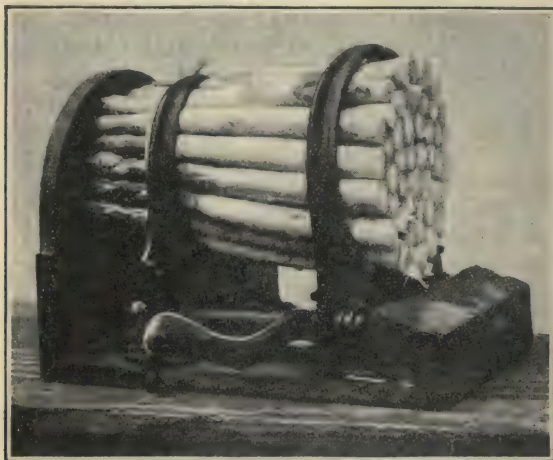


FIGURE 5.—One type of asparagus-bunching device. Note that the spears have been cut to a uniform length.

market made for this purpose (fig. 5). Some of the large plantations are equipped with machinery that cuts the spears to the desired length; however, most of the trimming is done by hand. A large number of spears can be trimmed at one operation by placing them in a frame which holds all the tips even, and the extra length of stem can then be cut off with a large knife. Where a small

bunching machine is used the spears are usually cut to the right length while the bunch is held in the buncher.

The bunches should be tied near each end. Some growers tie only once, at a point near the center; but a single tie makes a very poor bunch, as it permits too much slipping of the spears. Besides making a tighter bunch, the double tying adds to the appearance. Various materials, such as raffia, twine, and tape, are used for tying the bunches. While tying tape is a little more expensive than the other materials, it has much to recommend it. Raffia does not have the neat appearance of tape, and twine is likely to cut the spears if tied very tightly. The tape is available in various colors, and sometimes the several grades are tied each with different-colored tape. However, only good grades of tape having fast colors should be used, as any coloring of the spears from dye in the tape may impair the market value.

The bunches should be tied as tightly as possible without injuring the stalks, as there is some shrinkage of the spears, especially if they are bunched while very turgid. This shrinkage causes the bunches to become loose.

Many growers and shippers wrap the bunches in parchment paper, leaving a portion of the tip end of the spears extending above the paper, making a neat-appearing bunch. The paper wrapper generally bears the name and address of the grower or shipper. This is a good way to advertise a high-quality product.

PACKAGES

Shipping crates of different types are used in the various sections where asparagus is grown. The most commonly used crate is pyramidal in form (fig. 6), having two compartments each holding six 2-pound to 2½-pound bunches. A typical pyramidal crate and one used in California is 11 inches deep, 9 inches wide at the top and 11



FIGURE 6.—Asparagus packed in crates ready for market. Note the pyramidal shape of the containers.

inches wide at the bottom, and 18 inches long. A similar crate is used in Georgia and the Carolinas. The tendency in most States is toward this type of crate. Different States may use pyramidal crates having slightly different dimensions. This is a very satisfactory shipping container, as the pyramidal shape conforms to the taper of the bunches, preventing their being shifted about in shipment.

It is hoped that soon a standard crate will be adopted by all of the principal producing States, thereby eliminating much of the confusion that now exists as a result of use of crates of different sizes and dimensions.

New Jersey, Delaware, Maryland, and Pennsylvania have not adopted a standard-size container, but a dozen-size crate without a center partition is in general use.

Illinois still uses a flat, compartment crate holding two dozen bunches. A typical crate of this kind is 6 by 8 by 20 inches long.

The bottoms of the crates are generally lined with paper, which is covered with a layer of damp moss. The butts of the bunches are placed on the moss, and when packed in this way and kept at a temperature just about freezing, asparagus will carry a considerable distance and keep for several days without serious loss in quality.

In the early part of the cutting season when the quantity is small and where the product is to be sold in nearby markets, asparagus is shipped either by express or by motortrucks without refrigeration. After the cutting becomes heavy and carlot shipments begin, most of the asparagus is shipped under refrigeration.

No one factor is of more importance in the selling of a product than its appearance. The grower is usually well repaid for a little effort to make his produce command attention when it goes on the market. Care in grading, bunching, tying, and wrapping should add considerably to the selling qualities of an asparagus crop.

ASPARAGUS RUST¹

Asparagus is subject to a number of diseases, but only one, asparagus rust, is of much economic importance in asparagus production. The occurrence of this disease in North America was first mentioned by Halsted, who reported epidemics of rust on asparagus in New Jersey, Delaware, Long Island, and some parts of New England in 1896. Since then the rust has spread to practically every asparagus-producing section.

The presence of the disease is closely related to environmental conditions. Although the rust is present in most places where asparagus is grown, it is much more destructive in some localities than in others. The rust spores are dependent on moisture for germination, hence lack of moisture retards the spread of the disease. In the semiarid West the rust spreads very slowly, on account of the lack of moisture necessary for the germination of the spores. Severe rust epidemics are most likely to occur in regions of heavy rainfall and in localities subject to heavy dews.

The disease is generally first observed as small reddish-yellow spots on the main stems near the ground and on the very slender branches of the stalks which grow up after the cutting season is over. The red spots are due to numerous spore-bearing pustules on the stems. These pustules burst, liberating great numbers of rust spores, which have the appearance of reddish or rust-colored powder. By close examination of the stems the pustules may be found before they become numerous enough to attract attention. The spores liberated from the pustules are rapidly disseminated by the wind, and an entire field may soon become red with rust if sufficient moisture is present.

When the attack is severe the entire plant or the entire field may become brown and appear dead. The disease causes the tiny leaves to fall, and the plants present a naked appearance, as shown in figure 7. The effect of rust on a field of asparagus is shown in figure 8. The damage caused by the rust organism is not seen directly in the marketed product. The injury develops after the cutting season and reduces the succeeding crop by weakening or killing the plants during the summer. It is due largely to the destruction of the tissues which function in the manufacture of food materials for storage in the

¹ The section on asparagus rust was originally prepared by J. B. Norton, formerly of the Office of Cotton, Truck, and Forage Crop Disease Investigations, and has been revised by W. W. Gilbert, senior pathologist, at the Division of Fruit and Vegetable Crops and Diseases.

fleshy roots. The removal of the stalks for market during the harvest season is a heavy drain upon the roots. In order that the plant may replenish the reserve food supply for the next season's crop, it must



FIGURE 7.—Seedlings of Argenteuil asparagus, showing resistance to rust (above).
The new pedigreed Washington asparagus, highly resistant to rust (below).
Photographed by J. B. Norton, Concord, Mass.

make a vigorous top growth after the harvest season is over. If the tops are injured by the rust, food manufacture and translocation are checked, and the plants if not killed may go into the winter in a

starved condition. As a result, the succeeding crop suffers a reduction in both the number and the size of the shoots produced.

The most satisfactory way to control asparagus rust is to plant varieties known to be resistant to the disease. The most rust-resistant variety of asparagus in cultivation is the Martha Washington. The Mary Washington, while slightly less resistant than the Martha Washington, is sufficiently resistant for planting except where rust attacks are very severe. The Mary Washington has some other qualities, such as earliness and large size, that make it especially desirable for general planting. Plants of these rust-resistant varieties can be secured from most dealers in seeds and plants.

However, in spite of the fact that thousands of acres of rust-resistant strains of asparagus have been planted during the past few years, a certain proportion of the asparagus acreage throughout the country still consists of stocks that are susceptible to rust (fig. 8).



FIGURE 8.—An old asparagus field killed out by rust. The new field of the Reading Giant variety on the left was grown as a breeding field for rust-resisting work.

Several years must elapse before these nonresistant stocks will be entirely replaced by rust-resistant strains as their value becomes better understood. Meanwhile, in sections where rust is a factor and it is not practicable to do away with susceptible varieties, all practicable measures should be taken to reduce rust damage.

To this end the most important factor is to keep the rust away from the fields in early summer just as long as possible. Wild asparagus plants growing around the borders of the fields and along fences, hedges, or ditches are the worst enemies of the asparagus growers, because they carry the rust disease over winter and act as sources of infection for nearby fields in the spring. Most epidemics of rust start from asparagus plants in the field that have not been cut up to the close of the infection period of the spring rust or from infected wild plants near by, usually on the windward side of the infested area, since the spores of the rust fungus are carried by the wind. For

this reason wild plants wherever found should be dug up and burned, small shoots or seedlings should not be allowed to grow up in the field until the end of the cutting season, and new beds when started should be planted with rust-resistant strains or located as far as possible from the cutting beds and on the side opposite the prevailing winds. In the fall the tops should be removed from the 1-year-old beds that are to be cut the next year. This practice will largely reduce the danger of infection from this source.

The removal of the tops from mature beds in the fall is not considered important as a rust-control measure, since repeated tests have shown that the spring stage of the rust fungus does not occur in fields where the tops are left over winter, disked in the spring, and the field kept clean of asparagus until the end of the cutting season.

Spraying and dusting with different fungicides have met with varied success in different sections. Bordeaux mixture and sulphur dust were not entirely satisfactory. The best results have been obtained in California with sulphur dust applied when the plants are wet with dew. A finely divided sulphur was used, and the first application of 25 to 30 pounds per acre was made about 3 weeks after the close of the cutting season. Another application about a month later should be sufficient under ordinary conditions to hold the rust in check. On newly planted beds or when cutting stops early in the season more than two applications may be necessary.

INSECT PESTS ²

ASPARAGUS BEETLE

The asparagus crop is subject to injury by several pests, but the one of the greatest widespread importance is the asparagus beetle (*Crioceris asparagi* L.). This insect overwinters in the adult or beetle stage under the protection furnished by rubbish and other debris surrounding the cultivated fields. Emerging from overwintering quarters in the early spring, it injures the market product by feeding and depositing eggs upon the young shoots of the asparagus after they appear aboveground. Later in the season both the beetles and immature forms attack the fully developed plant. As previously stated, the eggs are laid in the early spring upon the marketable shoots, but later in the season they are deposited on the leaflets and stems of the upper parts of the mature plant. The small dark-colored larvae or slugs upon hatching from the eggs feed upon the foliage of the plant and in cases of heavy infestations defoliate large areas in a comparatively short time. It requires from 10 days to 2 weeks for the larvae to complete their development. Upon reaching maturity they drop from the plant to the ground and there form small cases or cocoons in which to transform to the pupal stage. After about a week or 10 days in this stage they emerge as adults.

There may be one or more generations during a season, depending upon the climate. During the hot summer months, however, the insect apparently does not thrive. Most of the damage to the crop

² Prepared by W. H. White, principal entomologist, Division of Truck-Crop and Garden Insects, Bureau of Entomology and Plant Quarantine.

is therefore caused in the spring and early summer. The attack upon the asparagus shoots during the early season reduces their market value because of the feeding marks and the presence of numerous small eggs which are difficult to remove. The younger plantings of asparagus are also subject to severe injury during the early part of the year. Later in the season the fully developed plants may receive a setback through defoliation by both larvae and adults.

Control.—No entirely satisfactory method has been developed for the protection of the market product from damage by the asparagus beetle. Keeping the pest in check by the use of arsenicals on the mature plantings and cleaning up the areas about the asparagus fields, however, will serve in a large measure to prevent noticeable losses. In regions comparatively free from rust attack, advantage may be taken of the fact that the female beetles prefer to lay their eggs on the full-grown asparagus plants rather than on the shoots. A number of the plants throughout the field, or a row of plants along the edges of the field, may be allowed to develop to serve as trap plants for the adults. As the insects collect on these plants they can be destroyed by any convenient means, such as, in the case of small plantings, knocking the beetles from the plants into a shallow pan containing a small quantity of kerosene, or dusting the plants with an arsenical. One part of calcium arsenate to 10 parts of hydrated lime applied in the form of a dust should give satisfactory results. This treatment can be used on young plantings and later in the season on the fully mature producing fields.

On small plots a hand duster may be used to advantage in applying the material. Large areas can be treated with saddle dust guns, such as are used in dusting cotton, or with traction dusters the nozzles of which are properly adjusted to the crop.

The larvae readily succumb to treatments with hydrated lime alone. They are also very susceptible to heat, and if they are jarred from the plant during hot periods onto freshly cultivated soil, many will die before reaching the plant again.

CUTWORMS

Cutworms (larvae of moths of the family Noctuidae) frequently become troublesome in asparagus plantings, both by cutting off the shoots and by feeding on the tips of the shoots as they appear above the ground. A suitable poisoned-bran bait, in the following proportions, applied directly to the affected area, is a satisfactory method of controlling these pests:

Dry bran.....	1 peck or 5 pounds.
White arsenic or paris green.....	$\frac{1}{4}$ pound.
Sirup or molasses.....	1 pint.
Water.....	3 or 4 quarts.

Or, in large quantities:

Dry bran.....	25 pounds.
White arsenic or paris green.....	1 pound.
Sirup or molasses.....	2 quarts.
Water.....	15 to 20 quarts.

(1) Thoroughly mix the poison with the bran. This is important. Each particle of bran must carry a little poison in order to get a good kill. When making small quantities, mix the materials in a bucket with a paddle, adding

the poison slowly and stirring the bran at the same time. A still more effective way is to mix the poison and bran with the hands; but, since soluble arsenic is absorbed to a slight extent through the skin, there may be some objection to this method. If the hands have any cuts, scratches, or other wounds, do not put them into the bait. When making large quantities mix the poison with the bran on some flat, smooth surface, using a shovel and rake in much the same way as in mixing concrete.

(2) Mix the sirup with the water.

(3) Put the poison bran in a bucket or washtub and gradually add the water-and-sirup solution, stirring slowly all the time. A large quantity of water added at one time will wash the poison from the bran, and an uneven mixture will result.

CAUTION.—Add only enough liquid to make a crumbly mass. It is a good plan to set aside a little of the mixture of dry bran and arsenic so that if too much water has been used this dry reserve can be added to bring the mixture up to the proper consistency.

Either broadcast the poisoned bait or sow it by hand along the rows. Do this late in the evening so that the bait will not dry out to any great extent before the worms become active. From 10 to 15 pounds of the wet bait per acre is enough for one application. Where the bait is applied directly to the rows the smaller quantity will be sufficient. It may require two or three applications at 2-day intervals to rid the fields of the pests.

GARDEN CENTIPEDES

In certain parts of California a pest known as the garden centipede (*Scutigera immaculata* Newp.) has become at times very destructive to large areas of asparagus. This centipede feeds below the surface of the ground on the succulent shoots of the asparagus plant. Considerable work has been done by the University of California on the control of this pest, and F. H. Wymore³ reports that it is most successfully combated by flooding. The ground should be covered with water to a depth of from 1 to 3 feet for a period of 3 weeks during the latter part of December and the first part of January. Many soil fumigants have been tried in an effort to control this centipede, but no satisfactory chemical method of control has been developed.

³ WYMORE, F. H. Biology and Control of the Garden Centipede *Scutigera immaculata* (Newport). Jour. Ent. and Zool. 16 (3): [73]–88, illus. 1924.

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U. S. DEPARTMENT OF
AGRICULTURE

FARMERS' BULLETIN No. 1647

GAME LAWS

FOR THE SEASON
1930-31

*A Summary of the Provisions
of Federal, State, and Provincial
Statutes*



THE thirty-first annual summary by the Department of Agriculture of Federal and other game laws and regulations is here presented for the use of law-enforcement officials, sportsmen, conservationists, and others as an aid in the administration of the migratory-bird treaty and Lacey Acts. The provisions as set forth furnish a brief and convenient synopsis of the laws. Provisions relating to methods of capture, game refuges, enforcement of laws, disposition of fees and fines, and minor matters are omitted, as also are texts of Federal and Canadian laws and regulations relating to birds and game. Illustration on the title-page of this bulletin is of redhead ducks (*Nyroca americana*) from a drawing by E. L. Poole.

Washington, D. C.

Issued September, 1930.

OFFICIALS FROM WHOM COPIES OF GAME LAWS MAY BE OBTAINED AND TO WHOM VIOLATIONS MAY BE REPORTED

[Violations of Federal game laws may be reported to the Chief, Bureau of Biological Survey, United States Department of Agriculture, Washington, D. C., or to the nearest United States game or reservation protector, a list of whom appears on page 46]

- Federal laws:** Secretary of Agriculture, Washington, D. C.
- Alabama:** Department of Game and Fisheries, Montgomery.
- Alaska:** Executive Officer, Alaska Game Commission, Juneau; or Secretary of Agriculture, Washington, D. C.
- Arizona:** State Game Warden, Phoenix.
- Arkansas:** Secretary, Game and Fish Commission, Little Rock.
- California:** Executive Officer, Fish and Game Commission, Russ Building, San Francisco.
- Colorado:** State Game and Fish Commissioner, Denver.
- Connecticut:** Superintendent of Fisheries and Game, Hartford.
- Delaware:** Chief Game and Fish Warden, Dover.
- District of Columbia:** Superintendent Metropolitan Police, Washington.
- Florida:** State Game Commissioner, Tallahassee.
- Georgia:** Game and Fish Commissioner, Atlanta.
- Hawaii:** Executive Officer, Fish and Game Commissioners, Honolulu.
- Idaho:** Fish and Game Warden, Boise.
- Illinois:** Director, Department of Conservation, Springfield.
- Indiana:** Superintendent of Fisheries and Game, State House, Indianapolis.
- Iowa:** State Fish and Game Warden, Des Moines.
- Kansas:** State Fish and Game Warden, Pratt.
- Kentucky:** Executive Agent, Game and Fish Commission, Frankfort.
- Louisiana:** Commissioner of Conservation, Court Building, New Orleans.
- Maine:** Commissioner of Inland Fisheries and Game, State House, Augusta.
- Maryland:** State Game Warden, 512 Munsey Building, Baltimore.
- Massachusetts:** Director, Division of Fisheries and Game, State House, Boston.
- Michigan:** Director, Department of Conservation, Lansing.
- Minnesota:** Game and Fish Commissioner, Department of Conservation, St. Paul.
- Mississippi:** Secretary of State, Jackson; or Sheriff or County Clerk.
- Missouri:** Game and Fish Commissioner, Jefferson City.
- Montana:** State Fish and Game Warden, Helena.
- Nebraska:** State Game Warden, Lincoln.
- Nevada:** Secretary, State Fish and Game Commission, Reno.
- New Hampshire:** Fish and Game Commissioner, Concord.
- New Jersey:** Secretary, Board of Fish and Game Commissioners, Trenton.
- New Mexico:** State Game Warden, Santa Fe.
- New York:** Chief Game Protector, State Office Building, Albany.
- North Carolina:** Director, Department of Conservation and Development, Raleigh.
- North Dakota:** Game and Fish Commissioner, Bismarck.
- Ohio:** Conservation Commissioner, Department of Agriculture, Columbus.
- Oklahoma:** State Fish and Game Warden, Oklahoma City.
- Oregon:** State Game Warden, Portland.
- Pennsylvania:** Executive Secretary, Board of Game Commissioners, Harrisburg.
- Rhode Island:** Chairman, Commissioners of Birds Providence.
- South Carolina:** Chief Game Warden, Columbia.
- South Dakota:** Director, Game and Fish Commission, Pierre.
- Tennessee:** State Game and Fish Warden, Nashville.
- Texas:** Game, Fish, and Oyster Commission, Austin.
- Utah:** Fish and Game Commissioner, Salt Lake City.
- Vermont:** Fish and Game Commissioner, Montpelier.
- Virginia:** Executive Secretary, Commission of Game and Inland Fisheries, Richmond.
- Washington:** Supervisor of Game and Game Fish, 404 Bell Street Terminal (P. O. Box 384), Seattle.
- West Virginia:** Game, Fish, and Forestry Commission, Charleston.
- Wisconsin:** Conservation Director, Madison.
- Wyoming:** State Game and Fish Commission, Cheyenne.
- Canada:** Commissioner, National Parks of Canada, Ottawa.
- Alberta:** Game Commissioner, Edmonton.
- British Columbia:** Game Commissioner, Vancouver.
- Manitoba:** Chief Game Commissioner, Winnipeg.
- New Brunswick:** Chief Game Warden, Fredericton.
- Northwest Territories:** Director, Northwest Territories and Yukon Branch, Department of Interior, Ottawa, Ontario.
- Nova Scotia:** Minister of Lands and Forests, Halifax.
- Ontario:** Department of Game and Fisheries, Toronto.
- Prince Edward Island:** Game Inspector, Provincial Treasury Department, Charlottetown.
- Quebec:** General Superintendent of Fisheries and Game, Quebec.
- Saskatchewan:** Game Commissioner, Regina.
- Yukon:** Territorial Secretary, Dawson.
- Newfoundland:** Secretary, Game and Inland Fisheries Board, St. Johns.
- Mexico:** Secretaria de Agricultura y Fomento, City of Mexico.

GAME LAWS FOR THE SEASON 1930-31

A SUMMARY OF FEDERAL, STATE, AND PROVINCIAL STATUTES

By FRANK L. EARNSHAW and FRANK G. GRIMES, *Administrative Assistants*
Division of Game and Bird Conservation, Bureau of Biological Survey

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FEDERAL MEASURES FOR GAME CONSERVATION

"GAME LAWS," so called, are a necessary and even a vital factor in the problem of game conservation. The mere enforcement, however, of the police provisions of such laws relating to close seasons and bag limits is in itself inadequate to offset the losses occasioned by the constantly increasing number of gunners and the reduction of feeding, nesting, and breeding areas caused by the drainage of swamp lands and by the steadily advancing march of civilization. The prime purpose of game laws is to conserve game, and the apprehension and the conviction of game-law violators are necessary though incidental functions in the broad field of operations involved in the administration of such laws. The replacement of our wild-life resources is equal in importance to the limitation of shooting seasons and bag limits.

Observations during the past few years have developed the fact that conditions surrounding wild life have been seriously adverse to its welfare and have demonstrated the necessity of adopting measures to offset the more harmful of these. The rapid extension of good roads and the increasing use of automobiles and motor boats serve to bring within easy reach of gunners areas that have heretofore been difficult of access. The resultant effect of this has been to cause increasing numbers of gunners to invade areas that by reason of their former isolation were natural wild-life sanctuaries. Sportsmen's organizations generally have recognized the necessity of increasing the supply of wild game to offset the enormous annual kill, and have sought to meet the situation in various ways. These include voluntary provision of rest days, setting aside certain portions of shooting areas as sanctuaries, and propagating and liberating game birds. Congress also has taken note of the necessity of replenishing the wild-life resources of the country by providing for the acquisition of land and water areas in various parts of the country to be set aside as inviolate sanctuaries, and by the enactment of other legislation of a beneficial character. Many areas that have been frequented by our game animals and birds can and must be reclaimed, improved, and reserved as sanctuaries if the species are to have opportunity to recoup.

The Bureau of Biological Survey now administers 86 game and bird reservations. Five of these are primarily big-game preserves, one is a muskrat and beaver preserve, and birds are protected on all but one. Among the most important, from the viewpoint of their value as breeding, feeding, and resting grounds for migratory game birds, are the Upper Mississippi River Wild Life and Fish Refuge, administered jointly by the Departments of Agriculture and Commerce, the Bear River (Utah) Migratory Bird Refuge, and the bird refuges at Big Lake in Arkansas, Malheur and Upper Klamath Lakes in Oregon, Tule Lake in California, and Benton Lake in Montana.

At the Bear River Migratory Bird Refuge in Utah, authorized by Congress, contracts have been let for construction work and improvements to correct conditions that have proved so destructive to waterfowl through alkali poisoning. A river-control structure provides a means of diverting the fresh-water supply at will, and there are to be feeder canals leading into the several units. A massive

outer dike, 20 miles long, will hold back sufficient water to flood about 25,000 acres of land.

The Benton Lake Bird Refuge in Cascade and Chouteau Counties, Mont., near the city of Great Falls, was created by Executive order of November 21, 1929. It includes an area of 12,234 acres and constitutes an important sanctuary for great numbers of migratory waterfowl. Normally, more than 3,000 acres of the refuge are under water, with an abundance of aquatic plant growth for cover and food for the birds. During their migrations, several species of wild ducks as well as wild geese are found on the Benton Lake marshes, and some of them breed there. Shore birds also frequent the region, chiefly in migration.

Two other wild-life refuges also have been established under Executive order since the last bulletin on the game laws was issued. One of these, known as Wolf Island Wild Life Refuge, on a portion of Wolf Island, off the coast of Georgia, between Doboy Sound and Altamaha Sound, was set aside by Executive order of April 3, 1930. This island was formerly used by the Department of Commerce as a lighthouse station, but was abandoned. Although comparatively small in size (575 acres), the area is important as a resting and feeding ground for waterfowl and other aquatic birds. The other, known as the Salt Plains Wild Life Refuge, a tract of approximately 20,600 acres in Alfalfa County, Okla., was set aside under Executive order of March 26, 1930, as a refuge and breeding ground for birds. This will constitute an important link in the chain of refuges to be established throughout the country under the migratory bird conservation act.

On July 1, 1929, funds became available for investigational work under the migratory bird conservation act, and examinations were started to ascertain essential facts concerning numerous areas recommended as suitable for wild-fowl refuge purposes. These investigations have followed two lines: (1) Surveys of food resources, existing and potential, of 189 units in 48 States, with an aggregate area of approximately 3,700,000 acres; and (2) intensive examinations, including valuations of the areas embraced within desired units, to determine accurately types of land, uses to which put, ownership, and the character, extent, and value of existing improvements. To June 30, 1930, this work has been conducted in 24 States, covering 40 units, and data and maps have been compiled covering a total of approximately 1,225,000 acres of land and water.

As a result of these studies, two areas of Federal lands have been withdrawn by Executive order, and further investigations with that end in view are in progress on five others. Since April 1, 1930, negotiations for the purchase of eight refuge sites have been conducted, and on May 25, 1930, the Migratory Bird Conservation Commission approved the purchase of 32,555 acres in the Cape Romain region in South Carolina, and 5,180 acres in the San Luis Lake region of Colorado.

REVIEW OF LEGISLATION OF 1930

REFUGES

Legislation enacted by Congress during the past year provides for the acquisition of not to exceed 20,000 acres of land and water in what is known as the Cheyenne Bottoms in Barton County, Kans., as an inviolate migratory-bird sanctuary. An appropriation of \$50,000 of a total authorization of \$250,000 for carrying out the project will enable the Biological Survey to begin preliminary operations for the acquisition of the area, which will provide both resting and breeding grounds for the birds traversing the Great Plains.

FEEDING GROUNDS

An item in the current rivers and harbors appropriation act authorizes the construction of a tidal guard lock, at a cost not to exceed \$500,000, in the Chesapeake and Albermarle Canal, near Great Bridge, in the Back Bay district of Virginia. This lock will prevent the influx of salt water into that great waterfowl region and thus preserve from destruction vast areas of valuable plant and other game food.

CONGRESSIONAL INVESTIGATIONS

The Senate, on April 17, 1930, appointed a committee of five members, all recognized wild-life conservationists, to investigate matters pertaining to the replacement and conservation of wild-animal life, including aquatic and bird life, with a view to determining the most appropriate means of accomplishing this end. This committee is now assembling data on the subject, both by

correspondence and by personal investigations and studies in the various States. Its findings and recommendations will be submitted to the Senate.

IMPORTATIONS

A provision of the tariff act of 1930 forbids the importation of wild animals or birds, dead or alive, from countries that restrict the killing, possession, or exportation of them to the United States, unless accompanied by a certificate of the United States consul for the district from which the mammals or birds are exported that they have not been acquired or exported in violation of the laws of such country. The provision does not apply to migratory game birds brought in by sportsmen returning from hunting trips, if at the time of importation the possession of such birds is not prohibited.

The new tariff act also permits the free importation of game mammals and birds for stocking purposes and game mammals and birds killed in foreign countries by residents of the United States if imported for noncommercial purposes.

FEDERAL REGULATIONS

BAG LIMITS

Amendments to the Federal regulations under the migratory-bird treaty act were approved by the President on December 31, 1929, and on May 23 and August 25, 1930. The outstanding amendment was the reduction of the bag limit on wild ducks from 25 to 15 a day and on wild geese from 8 to 4 a day with provision for a maximum limit of not to exceed 30 wild ducks and 8 wild geese in possession at any one time. This amendment automatically reduces the legal daily bag limit on these species in States where a larger limit is allowed under State law. In States having limits lower than those prescribed by the Federal regulations, the lower limits prevail.

In Alaska the bag limit on large brown and grizzly bears was reduced from 3 to 2 a season for nonresidents, with no limit for residents, except that only 2 may be taken in those areas where restrictions on hunting them are prescribed for residents. The limit on mountain goats was reduced from 3 to 2 a season.

SEASONS

In the absence of regulations providing definite open seasons on black-bellied and golden plovers, greater and lesser yellowlegs, wood ducks, eider ducks, and swans, the close season on these species is continued for an indefinite period. Wilson's snipe and woodcock are the only shore birds that may legally be killed.

A uniform season on waterfowl, October 1 to January 15, was fixed for the entire State of Washington, instead of the separate seasons previously existing east and west of the Cascades, and the same season for Massachusetts, instead of separate seasons for the insular counties of the State.

The season on mourning doves was closed in Ohio, Indiana, and Colorado to conform with close seasons under State laws; and for three southern counties of Florida a separate season, September 16 to November 15, was fixed on doves, the season for the rest of the State remaining October 16 to January 31. The dove season for Texas was changed to the period September 1 to October 31 in the north zone and October 1 to November 30 in the south zone, and State seasons were made to harmonize therewith.

Amendments to the Alaska game-law regulations, which became effective July 1, 1930, change the season on male deer in southeastern Alaska, east of longitude 138°, from the period September 1 to November 30 to the period August 20 to November 15, and provide the same season on mountain goat as that on mountain sheep, August 20 to December 31. An open season throughout the year was provided on black and polar bears in district 1. Residents are permitted to kill large brown and grizzly bears at any time except in certain specified areas, where the season is September 1 to June 20; in these areas a resident is permitted to kill these bears at any time when they are about to attack or molest persons or property.

RESTRICTIONS ON HUNTING

Under the amendments to the Alaska regulations, game mammals or game birds may not be hunted in the Keystone Canyon closed areas, including half a mile each side of the Richardson Highway from Valdez to the center of Snowslide Gulch; and caribou may not be hunted in Steese Highway closed areas, including half a mile each side, from Twelve-Mile Summit to Eagle Summit.

CANADIAN REGULATIONS

Amendments to the Canadian regulations on migratory game birds, approved by order in council June 14, 1930, change the season on ducks, geese, brant, coot, and rails in Prince Edward Island from the period September 1 to December 14 to the period September 15 to December 31; and shorten the season one month on ducks, geese, brant, and coot in Creston electoral district in British Columbia by closing on November 30. The season on band-tailed pigeons in British Columbia was extended 15 days, the new season being September 15 to October 15.

The daily bag limit on ducks for New Brunswick was reduced from 25 to 15, and a season bag limit of 150 established, and for Ontario the daily limit on ducks was reduced from 25 to 15 and the season limit from 200 to 150. The bag limit on ducks for Manitoba was reduced from 20 to 15 a day prior to October 1, and from 40 to 30 a day thereafter. The seasonal limit on ducks was reduced from 200 to 150, and a seasonal limit of 50 geese was also established for Manitoba.

The amendment also provides that no person shall kill or attempt to kill any migratory game birds in the Province of New Brunswick by the use of floating devices known as sinkboxes, or sinkboxes resting on the bottom, or by the use of any similar device or blind entirely surrounded by water between the hours of 1 p. m. and one hour before sunrise.

STATE AND PROVINCIAL LEGISLATION

Since the last bulletin on the game laws was issued, regular sessions of legislatures were held and laws concerning game enacted in nine States: Kentucky, Louisiana, Massachusetts, Mississippi, New Jersey, New York, Rhode Island, South Carolina, and Virginia. In other States changes were effected by regulation or order.

GAME-CODE REVISIONS

Massachusetts and Virginia completely revised their game codes. In Massachusetts licensees are now required to report during January the total number of each species of game mammal and bird taken. Another important provision requires the director of fisheries and game to adopt regulations conforming to changes in the Federal regulations with respect to migratory game birds. The new code permits the killing of deer with bow and arrow, and prohibits the importation and liberation of live game birds and animals except under permit.

In Virginia all special game laws of local application enacted in 1920 and previous years were repealed by the new code, as were also many of those enacted subsequent to 1920. A provision was reenacted making the State laws relative to the hunting and killing of migratory game birds automatically conform to the Federal regulations. Hunting of migratory waterfowl was prohibited east of the Blue Ridge Mountains on Wednesdays and Thursdays, and the special law governing the hunting of such birds on Back Bay in Princess Anne County was repealed. The main provisions of the old Back Bay law, however, including rest days on Wednesdays and Saturdays instead of Wednesdays and Thursdays, have been incorporated in regulations of the commission, thus the Back Bay law in effect being continued.

The new Virginia code increases the membership of the commission of game and inland fisheries from five to seven. In Kentucky the legislature increased the membership of the State game commission from four to five. In Mississippi a bill to create a State game commission of three members failed of passage, as did also a bill in Louisiana to make the State law on migratory game birds conform with Federal regulations.

LICENSES

Massachusetts adopted new license fees, to become effective January 1, 1931, and Virginia adopted a provision requiring nonresident anglers to obtain a license to fish with rod and reel in inland waters, including in the tidewater counties all brackish and fresh-water streams, creeks, bays, inlets, and ponds, and the fee for a reciprocal license with a minimum charge of \$2.50 was increased to a straight fee of \$5. Formerly nonresidents were not required to obtain an angling license in tidewater counties. The resident county certificate for killing bull elk in five counties was reduced from \$10 to \$2.50.

OPEN SEASONS

BIG GAME

In Massachusetts the season on deer was shortened from the period December 2 to 14 to the period December 1 to 6 throughout the State except in the four

western counties, where it remains the first two weeks of December, and in Nantucket County, where it is closed. In Virginia local seasons were prescribed in Prince George and Sussex Counties, and in South Carolina the season was closed in three counties. Arizona, by order, closed the season on black-tailed, or mule deer, south of the Gila River, and Georgia closed the season on deer in 19 counties. In West Virginia the season on male deer was opened for 10 days, December 1 to 10, except in two northern and two southern counties, where it remains closed. In British Columbia the season on male deer was extended in the western district by closing December 14 instead of November 30; on bull elk in Fernie and Columbia electoral districts it was similarly extended to open September 15 instead of October 1; and on mountain goat the season was extended throughout the Province (except on Vancouver Island, which is closed to big-game hunting) to close December 15 instead of November 30. In Maine the season was closed on bull moose throughout the State, and in British Columbia it was extended in the Columbia electoral district by opening on September 15, which is 16 days earlier than last year. In Mississippi the season on bear was closed throughout the State, and in Arizona it was closed in the region south of the Gila River.

SMALL GAME

Kentucky, Virginia, and South Carolina prescribed local seasons for squirrel and rabbit in certain counties, either by special local law or by regulation.

UPLAND GAME BIRDS

In Massachusetts an open season from October 20 to November 20 was provided on ruffed grouse, except in Dukes County, where the season remains closed. In New York the season on this species was opened for 15 days, October 1 to 15, except on Long Island, where it is November 1 to December 31, and in 12 southeastern counties, where it is October 15 to November 30. North Carolina closed the season on grouse until 1931, and Pennsylvania opened it from November 1 to 8. Connecticut opened the season on grouse from October 20 to November 23, which was also made to apply to Chinese, Mongolian, and English pheasants. Nova Scotia opened a season on ruffed grouse, October 16 to November 1. Tennessee enacted a law opening the season on wild turkeys throughout the State, November 15 to January 1, except in four counties, where the season is closed. South Carolina shortened the season on turkeys 13 days in one county, and Mississippi shortened it $2\frac{1}{2}$ months, by changing it from the period January 1 to March 31 to the period April 1 to 15. South Carolina shortened the quail season 23 days in 1 county, 1 month in 5 counties, and 13 days in 4 counties. Arizona closed the quail season in one county, and Nevada opened the season for 5 days, November 1 to 5, on both quail and pheasant. In Nevada the season was also opened on sage hen for 10 days, July 25 to August 3. By closing the season on prairie chicken in three counties, Oklahoma now affords complete protection for the species throughout the State.

BAG LIMITS

Massachusetts provided a bag limit of 3 ruffed grouse a day, 15 a season; Tennessee fixed the bag limit on turkeys at 3 a day; Arizona reduced the bag limit on quail from 20 to 15 a day or in possession; and Nova Scotia fixed the bag limit on ruffed grouse at 5 a day, 10 a season.

FEDERAL LAWS RELATING TO MIGRATORY BIRDS¹

Migratory birds included in the terms of the convention between the United States and Great Britain for the protection of migratory birds, concluded August 16, 1916, are as follows:

1. *Migratory game birds:*

- (a) Anatidae, or waterfowl, including brant, wild ducks, geese, and swans.
- (b) Gruidae, or cranes, including little brown, sand-hill, and whooping cranes.
- (c) Rallidae, or rails, including coot, gallinules, and sora and other rails.

¹ The full text of the migratory-bird treaty act and regulations and of other Federal laws affecting birds and game is contained in Service and Regulatory Announcement—B. S. No. 72, which may be obtained from the Department of Agriculture, Washington, D. C. Likewise the Canadian migratory-bird regulations may be obtained from the Commissioner, National Parks of Canada, Ottawa, Ontario.

(d) Limicolae, or shore birds, including avocets, curlews, dowitchers, godwits, knots, oyster catchers, phalaropes, plovers, sandpipers, snipe, stilts, surf birds, turnstones, willet, woodcock, and yellowlegs.

(e) Columbidae, or pigeons, including doves and wild pigeons.

2. *Migratory insectivorous birds*: Cuckoos; flickers and other woodpeckers; nighthawks or bullbats and whippoorwills; swifts; humming birds; flycatchers; bobolinks, meadow larks, and orioles; grosbeaks; tanagers; martins and other swallows; waxwings; shrikes; vireos; warblers; pipits; catbirds and brown thrashers; wrens; brown creepers; nuthatches; chickadees and titmice; kinglets and gnat catchers; robins and other thrushes; and all other perching birds which feed entirely or chiefly on insects.

3. *Other migratory nongame birds*: Auks, auklets, bitterns, fulmars, gannets, grebes, guillemots, gulls, herons, jaegers, loons, murre, petrels, puffins, shearwaters, and terns.

OPEN SEASONS UNDER FEDERAL REGULATIONS

Following are the provisions of the Federal regulations, with amendments of December 31, 1929, and May 23 and August 25, 1930, fixing open seasons on migratory game birds, which seasons are in some instances further shortened by State regulation (for dates during which a person may hunt these birds without violating either Federal regulations or State law, see the open seasons shown for the various States, beginning on p. 9):

Waterfowl (except wood duck, eider ducks, and swans), coot, and Wilson's snipe or jacksnipe.—The open seasons for waterfowl (except wood duck, eider ducks, and swans), coot, and Wilson's snipe or jacksnipe shall be as follows:

In Maine, New Hampshire, Vermont, Ohio, West Virginia, Michigan, Wisconsin, Minnesota, Iowa, North Dakota, South Dakota, Nebraska, Kansas, Colorado, Wyoming, Montana, Nevada, and that portion of Idaho comprising the counties of Boundary, Bonner, Kootenai, Benewah, and Shoshone, the open season shall be from September 16 to December 31;

In New York (except Long Island), Illinois, and Missouri the open season shall be from September 24 to January 7;

In Massachusetts, Rhode Island, Connecticut, Pennsylvania, Indiana, Utah, Idaho (except in the counties of Boundary, Bonner, Kootenai, Benewah, and Shoshone), California, Oregon, and Washington the open season shall be from October 1 to January 15;

In that portion of New York known as Long Island, and in New Jersey, Delaware, Oklahoma, New Mexico, Arizona, that portion of Texas lying west and north of a line beginning on the Rio Grande River directly west of the town of Del Rio, Tex.; thence east to the town of Del Rio; thence easterly following the center of the main track of the Southern Pacific Railroad through the towns of Spofford, Uvalde, and Hondo; thence to the point where the Southern Pacific Railroad crosses the International & Great Northern Railroad, at or near San Antonio; thence following the center of the track of said International & Great Northern Railroad in an easterly direction, to the point in the City of Austin, where it joins Congress Avenue, near the International & Great Northern Railroad depot; thence across said Congress Avenue to the center of the main track of the Houston & Texas Central Railroad where said track joins said Congress Avenue, at or near the Houston & Texas Central Railroad depot; thence following the center line of the track of said Houston & Texas Central Railroad in an easterly direction through the towns of Elgin, Giddings, and Brenham, to the point where said railroad crosses the Brazos River; thence with the center of said Brazos River in a general northerly direction, to the point on said river where the Beaumont branch of the Santa Fe Railway crosses the same; thence with the center of the track of the said Gulf, Colorado & Santa Fe Railway, in an easterly direction through the towns of Navasota, Montgomery, and Conroe, to the point at or near Cleveland, where said Gulf, Colorado & Santa Fe Railway crosses the Houston, East & West Texas Railroad; thence with the center of said Houston, East & West Texas Railroad track to the point in said line, where it strikes the Louisiana line, the open season shall be from October 16 to January 31, and in that portion of Texas lying south and east of the line above described the open season shall be from November 1 to January 31;

In Maryland, the District of Columbia, Virginia, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Arkansas, and Louisiana, the open season shall be from November 1 to January 31; and

In Alaska the open season shall be from September 1 to December 15.

Rails and gallinules (except coot).—The open season for sora and other rails and gallinules (except coot) shall be from September 1 to November 30, except as follows:

In Massachusetts the open season shall be from October 1 to December 15;

In New York the open season shall be from September 24 to November 30; and

In Louisiana the open season shall be from November 1 to January 31.

Woodcock.—The open seasons for woodcock shall be as follows:

In Maine, New Hampshire, Vermont, New York, and North Dakota the open season shall be from October 1 to October 31;

In Massachusetts, Rhode Island, and Connecticut the open season shall be from October 20 to November 19;

In New Jersey, Pennsylvania, Ohio, Indiana, Michigan, Wisconsin, and Iowa the open season shall be from October 15 to November 14;

In Maryland, the District of Columbia, and Missouri the open season shall be from November 10 to December 10;

In Delaware, Virginia, West Virginia, Kentucky, Arkansas, and Oklahoma the open season shall be from November 15 to December 15; and

In North Carolina, South Carolina, Georgia, Alabama, Mississippi, and Louisiana the open season shall be from December 1 to December 31.

Doves.—The open seasons for mourning doves shall be as follows:

In Delaware, Maryland, Virginia, Tennessee, Kentucky, Illinois, Minnesota, Nebraska, Kansas, Missouri, Arkansas, Oklahoma, New Mexico, Utah, Arizona, California, Nevada, Idaho, and Oregon the open season shall be from September 1 to December 15;

In that portion of Texas lying west and north of the zone line described above under "Waterfowl," the open season shall be from September 1 to October 31; and in that portion of Texas lying south and east of the line above described the open season shall be from October 1 to November 30;

In South Carolina, Georgia, Alabama (except in Mobile and Baldwin Counties), Mississippi, and Louisiana, the open season shall be from September 1 to September 30 and from November 20 to January 31;

In that portion of Alabama known as Mobile and Baldwin Counties, the open season shall be from November 1 to January 31;

In North Carolina the open season shall be from November 20 to January 31;

In Florida (except in Broward, Dade, and Monroe Counties) the open season shall be from October 16 to January 31; and

In that portion of Florida known as Broward, Dade, and Monroe Counties the open season shall be from September 16 to November 15.

BAG LIMITS AND OTHER PROVISIONS UNDER FEDERAL REGULATIONS

Bag and possession limits.—A person may take in any one day during the open seasons prescribed therefor not to exceed the following numbers of migratory game birds, which numbers shall include all birds taken by any other person who for hire accompanies or assists him in taking migratory birds; and in the case of ducks and geese when so taken these may be possessed in the numbers specified as follows:

Ducks (except wood duck and eider ducks), 15 in the aggregate of all kinds, 30 in possession.

Geese, 4 in the aggregate of all kinds, 8 in possession.

Brant, 8.

Coots, 25.

Sora, 25.

Rails and gallinules (except sora and coots), 25 in the aggregate of all kinds, but not more than 15 of any one species.

Wilson's snipe, or jacksnipe, 20.

Woodcock, 4.

Mourning doves, 25.

No other migratory birds may be taken at any time except under permit for propagating, scientific, or banding purposes, or under an order of the Secretary of Agriculture to prevent injury to agricultural or other interests.

Time of day and methods.—Migratory game birds may be taken from the land and water on any day during the open season from half an hour before sunrise to sunset with a gun not larger than 10 gauge, fired from the shoulder, with the aid of a dog, the use of decoys, and from a blind or floating device other than an automobile, airplane, power boat, sailboat, any boat under sail, or any floating device towed by power boat or sailboat, or any sinkbox (battery), except that sinkboxes (batteries) may be used in taking waterfowl in coastal sounds and bays (including Back Bay, Princess Anne County, Va.), and other coastal

waters; and the use of an airplane or a power boat, sailboat, or other floating device for the purpose of concentrating, driving, rallying, or stirring up migratory waterfowl is prohibited.

Possession.—Migratory game birds legally taken may be possessed during the period constituting the open season where killed and for an additional period of 10 days next succeeding such open season, and those coming from a country other than Canada may be possessed in the State into which they are brought only during the open season in that State and such additional time immediately thereafter as may be permitted by both Federal and State laws.

Interstate traffic in game.—Not more than two days' bag limit of migratory game birds, as prescribed by the Federal regulations, may be exported or removed from the State where taken in any one calendar week, and such migratory game birds or parts thereof in transit during the open season may continue in transit such additional time, not exceeding five days, as may be necessary for delivery at destination.

The Lacey Act prohibits interstate shipment by common carrier of wild animals or parts thereof where such animals have been killed or shipped in violation of the laws of the State in which killed or from which shipped, and section 4 of the treaty act likewise prohibits the removal in any manner from one State to another of any wild birds in violation of State laws or which have been illegally taken. All packages in interstate commerce containing game animals or nonmigratory game birds, or parts thereof, must be marked to show the names and addresses of the consignor and consignee and the nature of the contents, and packages containing migratory birds must be marked with such addresses and the number and kind of such birds therein.

Sale.—The Federal law prohibits the sale of all migratory birds throughout the United States except birds taken for scientific or propagating purposes and waterfowl raised on farms or preserves under permit from the Secretary of Agriculture.² Feathers of wild ducks and wild geese lawfully killed, and of such birds seized and condemned by Federal or State authorities, may be purchased and sold for use in the manufacture of fishing flies, pillows, and mattresses, but not for millinery or ornamental purposes.

Alaskan exceptions.—In Alaska, Eskimos and Indians may take for the use of themselves and their immediate families, in any manner and at any time, and possess and transport auks, auklets, guillemots, murres, and puffins and their eggs for food and their skins for clothing.

Permits for propagation and other purposes.—Under appropriate permit from the Secretary of Agriculture, and when allowed by State law, migratory waterfowl may be captured at any time for propagating purposes, and waterfowl bred in captivity may be killed and the carcasses sold and used for food purposes. Waterfowl captured and bred in captivity may also be sold alive for breeding and exhibition purposes to the holders of permits. Under appropriate permit all species of migratory birds, except whooping cranes, trumpeter swans, and Eskimo curlew, may be taken for scientific purposes, and all species may be taken for banding. The Secretary of Agriculture may also issue orders permitting the killing of migratory birds to prevent serious injury to agriculture or other interests.

Further restrictions by States.—The States may shorten the open seasons fixed by Federal regulations on migratory birds, reduce the bag limits, prohibit export, restrict the period during which migratory birds may be possessed in close season, or make other laws or regulations to give further protection to such birds, but may not lengthen the open season, increase the bag limit, permit sale or otherwise lessen the protection afforded by Federal law.

SUMMARY OF LAWS RELATING TO SEASONS, LICENSES, LIMITS, POSSESSION, INTERSTATE TRANSPORTATION, AND SALE

Game laws and information.—Persons are advised to obtain from State game commissioners the full text of game laws in States where hunting is contemplated. (See list on p. 11, back of title-page.) They should also obtain information from the Bureau of Biological Survey or State game departments³ regarding the existence of Federal and State game and bird refuges in areas in which they

² See footnote 1, p. 5.

³ See list on page 11 (back of title-page). A full list of names and addresses of officials and organizations concerned with the protection of birds and game will be found in Misc. Publ. No. 92, U. S. Dept. Agr., 1930.

contemplate hunting, as the location of refuges and the restrictions regarding hunting thereon are not included in this bulletin.

Open season dates.—The dates of open seasons for migratory game birds shown under the various States and Provinces are the times when these birds may be hunted without violating either State or Provincial laws or Federal or Canadian regulations.

In stating the open season ⁴ the plan has been followed of including the first and last days thereof. The difficulty of attaining absolute accuracy in a statement of the seasons is great, but summaries have been submitted to the proper State or provincial game officials for correction and approval, and the dates as stated are believed to be free from material errors.

Permanent close seasons.—Species (including migratory game ⁵ and nongame ⁵ birds—but not migratory insectivorous ⁵ birds—protected throughout each year by Federal regulations) on which the season is closed for a term of years or for an indefinite period are grouped under the term "No open season." Provisions of State laws prohibiting hunting at night, between sunset and sunrise, or during certain hours are not included.

Rest days.—In some States certain days of the week constitute rest days or close seasons during the time when hunting is permitted. Hunting on Sunday is prohibited in all States and Provinces east of the one-hundred and fifth meridian, except Illinois, Louisiana, Michigan, Rhode Island, Texas, Wisconsin, and Quebec. Mondays constitute a close season for waterfowl locally in California and North Carolina; Wednesdays for ducks and coot in Wisconsin; Wednesdays and Thursdays east of Blue Ridge Mountains in Virginia; and certain other week days for waterfowl in several favorite ducking grounds in California, Maryland, North Carolina, and Florida. In Oregon mountain and valley quail, Hungarian partridges, and Chinese pheasants may be hunted locally only on Wednesday and Sunday of each week during the open season. In Oklahoma quail may be hunted only on Monday, Wednesday, and Friday of each week during the open season, and on Thanksgiving Day and Christmas and New Year's Day, or the preceding Saturdays, if these fall on Sundays. Hunting is prohibited when snow is on the ground in New Jersey, Delaware, and Virginia, and locally on all game except waterfowl in Maryland.

Possession.—The provision of the Federal regulations permitting the possession of migratory game birds during the first 10 days of the close season has been considered in connection with State laws, and when migratory game birds may be possessed during any part of the close season without violating either the Federal regulations or State laws it has been stated under the heading "Bag limits and possession."

Possession of nonmigratory game during the close season is generally prohibited by State laws, but when an extension of a few days, or a special season, is provided for either possession or sale, attention is called thereto.

Interstate transportation.—Under the heading "Interstate transportation," in addition to statements of restrictions on removal of game from the State in which it is taken, information has been included concerning the importation and possession by sportsmen for personal use of game legally killed outside the State and legally exported from the place where taken. In the absence of specific State legislation to the contrary, or where legislation prohibits possession of game in close season, it has been construed that sportsmen may bring home their game and possess it in their State in the same manner as if it had been killed there.

Propagated and imported game.—For laws concerning traffic in imported game and game raised in captivity under Federal and State licenses, see pages 43 to 45.

STATE LAWS

ALABAMA

Open seasons: ⁴	Dates inclusive
Deer (male).....	Nov. 1-Dec. 31.
Beaver.....	Nov. 1-Feb. 28.
Squirrel (black, gray, fox).....	Nov. 1-Jan. 31. ⁷
Quail (partridge).....	Nov. 20-Feb. 20.
Wild turkey gobbler.....	Dec. 1-Mar. 31.
Duck, goose, brant, Wilson's snipe, coot (mud hen).....	Nov. 1-Jan. 31.
Woodcock.....	Dec. 1-Dec. 31.

Open seasons—Continued.	Dates inclusive
Rail and gallinule, other than coot.....	Sept. 1-Nov. 30.
Turtle dove (see exception).....	{Sept. 1-Sept. 30. Nov. 20-Jan. 31.
<i>Exception:</i> In Mobile and Baldwin Counties.....	
No open season: Ruffed grouse (pheasant), introduced pheasants, or other introduced game bird (1931); does, turkey hens, swans, wood duck,	

⁴ For open seasons on fur-bearing animals for the season 1930-31 see Farmers' Bulletin No. 1648.

⁵ For definitions, see pp. 5-6.

⁶ Alabama: Hunting prohibited on all State lands.

⁷ Squirrels may be killed at any time on own premises when destroying property.

bitterns, sand-hill and whooping cranes, grebes, gulls, herons, loons, shearwaters, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident or alien, game, \$25; fish, \$5. Resident: Game, State \$3; county, \$1. Trapping (bears and other fur-bearing animals), \$15 for first trap and \$2.50 for each additional trap. Issued by probate judges. Landlords and members of families may hunt or trap on own land during open season without license. Written permission required for hunting or trapping on land of another.

Bag limits and possession: One buck a day or in possession, 5 a season; 1 turkey gobbler a day or in possession, 10 a season; 10 squirrels a day or in possession; 15 quails a day or in possession; 4 geese a day, 8 in possession; 8 brant a day, 25 in possession; 20 Wilson's snipe a day, 25 in possession; 15 ducks a day, 30 in possession; 25 each of doves, coots, and sora a day or in possession; 25 in all of rails (except sora) and gallinules a day, but not more than 15 of any one species, 25 each in possession; 4 woodcock a day, 25 in possession. Possession of migratory game birds permitted during first 10 days of close season; other game during first 5 days.

Interstate transportation: Export of all protected game prohibited, except that a nonresident licensee may take with him, openly, game he has lawfully killed, but not more than two days' limit of migratory birds may be exported in any one calendar week.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of all protected game prohibited.

ALASKA

Open seasons: ^a	Dates inclusive
Bull moose (except yearlings and calves).....	Sept. 1-Dec. 31. ⁹
Caribou, south of Yukon River North of Yukon River.....	Aug. 20-Dec. 31. ¹⁰
Deer (male, with horns not less than 3 inches above skull), east of longitude 138° (south-eastern Alaska).....	No close season.
In rest of Territory.....	Aug. 20-Nov. 15.
Mountain sheep (rams), mountain goat (except kids).....	No open season.
	Aug. 20-Dec. 31. ⁹

^a Alaska: All hunting is prohibited in Mount McKinley National Park, Katmai and Glacier Bay National Monuments on Kruzof and Partofshikof Islands, in Eyak Lake closed area, and in Keystone Canyon closed area, including half a mile on each side of Richardson Highway from Valdez to Snowslide Gulch, and Curry and Alaska Railroad closed areas; and, except under permit of the Secretary of Agriculture, in Aleutian Islands Reservation (including Unimak Island) and other national bird and mammal reservations. An Indian, Eskimo, or half-breed who has not severed his tribal relations, and an explorer, prospector, or traveler may take mammals or birds other than migratory birds (except Eskimos and Indians may take auks, auklets, guillemots, and puffins, and their eggs) in any part of Territory at any time for food when in absolute need of food and other food is not available, but he shall not ship or sell any mammal or bird or part thereof so taken.

⁹ Unlawful to hunt moose on Alaska Peninsula south and west of Kvichak River, Iliamna Lake, and portage from Kamishak Bay to Kakhonak Bay; and mountain sheep or mountain goats on Kenai Peninsula east of longitude 150° (5 miles east of Stalter place on Kenai River); and mountain goats on Baranof and Chichagof Islands.

¹⁰ Unlawful to hunt caribou in Steese Highway closed areas, including half a mile on each side of highway at Twelve Mile Summit and Eagle Summit.

Open seasons—Continued.

Bear (large brown and grizzly).....	Dates inclusive Sept. 1-June 20. ¹¹
Black bear, polar bear (fur animals).....	No close season.
Grouse, ptarmigan.....	Sept. 1-Feb. 25.
Duck, goose, brant, Wilson's snipe or jacksnipe.....	Sept. 1-Dec. 15.

No open season: Buffalo; elk; calf, yearling, and cow moose; fawns and doe deer; mountain-sheep lambs and ewes; mountain-goat kids; fawns of caribou; swans, elder ducks, rails, coot, cranes, auklets, fulmars, grebes, guillemots, gulls, herons, jaegers, loons, murre, petrels, puffins, shearwaters, terns, and all shore birds (except Wilson's snipe or jacksnipe).

Hunting licenses: Nonresident citizen: General, \$50; small game, \$10; nonresident big-game hunter must be accompanied by registered guide except in fur district 3; licenses issued by commissioners, wardens, and special agents. Resident, \$2 (trapping license required for taking black bears, which are fur animals under the law; not required of native-born Indians, Eskimos, or half-breeds who have not exercised the right of franchise or severed their tribal relations). Alien, \$100 (special license required to hunt or possess firearms); issued by commission. Licensed hunters, within 30 days after expiration of license, must report to commission number and kind of each species of birds or animals taken.

Guide, \$10 (issued only to resident citizens or resident native Indian or Eskimo); issued by commission. Guide must report to commission after each hunting trip.

Shipping licenses: Resident (export for mounting and return), \$1 for each trophy; resident removing from Territory, \$5 for each trophy. Issued by commission or collector of customs.

Bag limits and possession: Caribou, nonresident 2, resident 5, a season (except on Alaska Peninsula, resident 2, nonresident 1); mountain sheep, nonresident 2, resident 3, a season, of which not more than 2 may be taken south of Arctic Circle; 1 moose, 3 deer, 2 mountain goats a season or in possession; 2 in all of large brown and grizzly bears a season or in possession (nonresident); no limit for resident except 2 only in certain areas where a season is prescribed for residents. Game animals legally taken during open season may be possessed and transported within Territory by any person at any time. Number of game animals in excess of season limit may be possessed under permit of commission; 15 grouse, 25 ptarmigan, but not more than 25 in all of grouse and ptarmigan a day; 15 ducks, 4 geese, 8 brant a day; 20 Wilson's snipe a day. Migratory game birds legally taken may be possessed during open season and 10 days thereafter, but not more than 50 in all of waterfowl may be possessed at one time of which not more than 30 may be ducks, and 8

¹¹ Season on large brown and grizzly bears applies throughout Territory to nonresidents. No closed season to residents except (1) in drainage to Gulf of Alaska from west shore of Glacier Bay to Alesek River, (2) drainage to Gulf of Alaska from west shore of Yakutat Bay and west edge of Hubbard Glacier to Bering River, (3) drainage to west side of Cook Inlet between west bank of Susitna River to its confluence with Yentna River, thence along west bank of Yentna River to its confluence with Skwentna River, thence along south bank of Skwentna River to summit of Alaska Range and the old portage from Kakhonak Bay on Iliamna Lake to Kamishak Bay, (4) all of Alaska Peninsula south and west of Kvichak River, Iliamna Lake, and old portage from Kakhonak Bay to Kamishak Bay, (5) and the following islands: Hawkins, Hinchinbrook, Montague, Yacobi, and Shuyak, where the open season to residents is September 1 to June 30; and in areas named a resident may kill a large brown or grizzly bear at any time or place when such animal is about to attack or molest persons or property.

geese. Game animals, grouse, ptarmigan, hides, heads, and feet of game animals or articles made therefrom and skins and feathers of game birds legally taken during open season may be possessed and transported at any time within the Territory, and shed antlers of deer, moose, or caribou may be possessed and transported within or out of the Territory at any time without a license.

Interstate transportation: Nonresident citizen or nonresident alien licensee may export 1 moose, 3 deer, 2 caribou (1 from Alaska Peninsula), 2 mountain sheep, 2 mountain goats, and 2 in all of large brown and grizzly bears killed by himself under license coupon and affidavit that he has not violated the game laws; that big-game animal or part thereof he desires to ship has not been purchased or sold and is not shipped for purpose of being sold; that he lawfully killed the animal and is owner of part thereof that he desires to ship, and, if shipment contains caribou or parts thereof, whether animal was killed on Alaska Peninsula.

A nonresident may possess and transport at any time within or out of Territory skins and feathers of game birds and articles manufactured from hides or hoofs of moose, caribou, deer, or goats legally taken. Any person may without a license export shed antlers of moose, caribou, or deer.

Resident may export for mounting and return in any one year, but not for sale, two heads or trophies of each species of game animal legally killed by himself under shipping license (fee, \$1 for each trophy).

A citizen of the United States who has been a resident for at least two years and who is removing his residence from Territory may export trophies of game animals legally acquired by him under shipping license (fee, \$5 for each trophy).

All shipments must be marked with names and addresses of consignor and consignee and number of each kind of game contained therein.

Sale: Sale of all protected game prohibited, except that meat of caribou may be sold by the person killing it, but such meat may not be resold north of summit Alaska Range-Ahklun Mountains except in cooked form, nor south of said summit except in cooked form and then only at road houses having permits from the commission; moose, grouse, and ptarmigan legally killed may be bought and sold at any time north of summit of Alaska Range and Ahklun Mountains, but no person other than the one who killed them may sell them except in cooked form for human food but meat of moose, grouse, or ptarmigan may not be sold or served by restaurants, road houses, or public or other eating houses located within 5 miles each side of the center line of Alaska Railroad and its branches; number of animals in excess of season limit allowed in possession under permit of commission. Meat of mammals or birds so sold shall not be transported to or possessed in any other part of Territory. No game animal, game bird, or parts thereof shall be sold to or bought by the owner, master, or employee of any coastal or river steamer or commercial power or sail boat; unlawful to take or possess for serving or to serve any game animal, game bird, or part thereof in any dining car, commercial mess house operated by a cannery, railroad, or contractor, or in any other commercial mess house or other place maintained for serving food regularly to employees thereof, or to serve such game to an employee of any coastal or river steamer or commercial power or sail boat, or for an employee of a railroad, cannery, mine, contractor, or coastal or river steamer or other commercial power or sail boat to possess such game in a dining car or commercial mess house, or in the galley or dining room of any such boat.

Any person may without a license buy and sell at any time in Territory feathers of wild ducks and geese, lawfully killed or seized and condemned by Federal game authorities, for use in making fishing flies, bed pillows, mattresses, and similar commercial purposes, but not for millinery or ornamental purposes; hides or parts of hides of moose, caribou, deer, and mountain goats legally taken during the open season; shed antlers of caribou, moose, and deer; and skins

and feathers of eagles, crows, hawks, owls, ravens, and cormorants.

ARIZONA

Open seasons: 12

Dates inclusive

Deer (male with pronged horn), bear, wild turkey (see exception).....	Oct. 16-Nov. 15.
Exception: Black-tailed or mule deer, bear, turkey, south of Gila River.....	No open season.
Peccary or javelina.....	Nov. 1-Jan. 31.
Squirrel (see exceptions).....	Sept. 1-Oct. 31.
Exceptions: Kaibab squirrels in State, and Chiricahua and Arizona tree squirrels south of Gila and Salt River base meridian.....	No open season.
Quail (Gambel's, scaled) (see exception).....	Nov. 1-Dec. 31.
Exception: In Navajo County.....	No open season.
White-winged dove.....	July 15-Aug. 31.
Mourning dove.....	Sept. 1-Dec. 15.
Duck, goose, brant.....	Oct. 16-Jan. 31.
Wilson's snipe, coot.....	Oct. 16-Nov. 30.

No open season: Does, spotted fawns, spike bucks, elk, antelope, mountain sheep, bobwhite and Mearns's quail, grouse, pheasant, swans, bitterns, little brown and sandhill cranes, grebes, gulls, herons, loons, band-tailed pigeons, terns, rails, gallinules, and all shorebirds except Wilson's snipe or jacksnipe.

Hunting and fishing licenses: Nonresident:

Game and fish, \$35; small game and fish, \$10; special 15-day fishing, \$2.50. Resident: Game and fish, \$2.50; fish, \$1.25. Alien: Game and fish, \$75; small game and fish, \$30. Special license, alien applicant for citizenship, game, \$25; alien applicant for citizenship, small game and fish, \$10. Guide, \$10. American-born resident or nonresident under 16 years of age may hunt and fish without license if accompanied by holder of a valid license.

Bag limits and possession: One deer, 1 bear, 1 peccary or javelina, 6 squirrels, 2 turkeys a season; 15 quail a day or in possession; 15 ducks a day or in possession; 2 geese, 2 brant a day or in possession; 15 in all of Wilson's snipe and coots a day or in possession; 20 doves. One male deer, 2 wild turkeys, or one day's bag limit of other game lawfully taken may be possessed for 10 days after close of season.

Interstate transportation: Nonresident licensee may ship one day's bag limit of game or fish a week under permit attached to his license, and may procure additional license for additional shipment. Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of all protected game prohibited.

Miscellaneous: Use of dog in taking game animals, except bear, prohibited.

ARKANSAS

Open seasons:

Dates inclusive

Male deer (with horns plainly visible above skull), turkey gobblers (gobblers also) Apr. 1-Apr. 30).....	Nov. 10-Nov. 15. Dec. 20-Jan. 1.
Squirrel (see exceptions).....	July 1-Jan. 1.
Exceptions: In Chicot, Desha, and Lonoke Counties.....	May 15-June 15. Oct. 1-Jan. 1.
In Ashley, Bradley, Calhoun, Cleveland, Columbia, Dallas, Drew, Garland, Grant, Hot Spring, Lafayette, Lincoln, Ouachita, and Union Counties.....	Oct. 1-Jan. 1.
In Marion County.....	No close season.
Quail or partridge (bobwhite). Duck, goose, brant, Wilson's snipe, coot.....	Dec. 1-Jan. 31. Nov. 1-Jan. 31.

¹²Arizona: Animals or birds (except migratory birds) that become seriously injurious to agriculture or other interests may be killed under permit of commission.

Open seasons—Continued.	Dates inclusive
Woodcock.....	Nov. 15-Dec. 15.
Dove.....	Sept. 1-Dec. 15.
Gallinule.....	Nov. 1-Nov. 30.
Rail, other than coot and gallinule.....	Sept. 1-Nov. 30.

No open season: Does, fawns, and wild-turkey hens; bears, prairie chickens, grouse, pheasants (1931); swans, wood ducks, bitterns, sand-hill and whooping cranes, grebes, gulls, herons, loons, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident: Game, \$15; fish, general, \$5; special 15-day (trip), \$1.10; resident: Game, \$1.10; fish, \$1.10. For dog in hunting, \$1.50. Issued by State game and fish commission and circuit clerks. Resident hunting license not required of person under 18 years of age. License not required of residents for hunting rabbits, squirrels, or predatory birds and animals or of a person hunting on his own premises. Hunting prohibited on inclosed lands without consent of owner.

County licenses.—**Chicot County:** Nonresident of State, \$50; resident of State: All game, \$5.25; game (except deer and turkey), \$2.25. Dog (for deer or quail hunting), \$1.10. **Desha County:** Nonresident of State, \$50; resident of State: All game, \$2.50; game (except deer and turkey), \$1.10. Dog (for deer or quail hunting), \$1. License not required of resident under 16 in Chicot and Desha Counties.

Bag limits and possession: Two deer, 2 turkeys a season; 8 squirrels, 12 quail, 25 doves, 15 ducks, 4 geese, 8 brant, 4 woodcock, 12 Wilson's snipe, 15 in all of rails, coots, and gallinules, a day or in possession. Two days' limit of squirrels, quail, or ducks may be possessed at one time, except while in the field hunting or while returning from a hunt of one day's duration. Possession of migratory game birds permitted during first 10 days of close season.

Interstate transportation: Export of all game prohibited; provided a nonresident, under each of 3 tags attached to his license may ship out 1 day's limit of game; and he may carry out at one time not more than 1 day's limit, but not more than 2 days' limit may be removed from State in any one calendar week; specimen of game may be exported by any person under permit to be mounted, tanned, or made into wearing apparel. Game taken outside of State and legally exported may be possessed in State at any time.

Sale: Sale of all protected game prohibited.

CALIFORNIA¹³

Open seasons:	Dates inclusive
Male deer (except spike bucks):	
In districts, 1, 4, 4½, 4¾, 23, 24, 25, and 26.....	Sept. 16-Oct. 15.
In district 1½.....	Sept. 1-Oct. 15.
In district 1¾ (mule deer must have more than two branches to each antler)....	Sept. 16-Oct. 15.
In districts 2, 2½, and 3.....	Aug. 1-Sept. 14.
Bear (black, brown) (see exception).....	Nov. 15-Feb. 28.
Exception: In districts, 1, 1½, 2, and 2½.....	No close season.

¹³ California: Of the 72 fish and game districts created under the act of 1917, as amended in 1929, nine (1, 1½, 1¾, 2, 2½, 3, 4, 4½, and 4¾) are properly hunting districts; 14, 15, 23, 24, 25, and 26 are fishing districts but are open to hunting; of the other 63 districts, 37 are game refuges, 9 are special fishing districts, and 17 are commercial fishing districts.

District 1 comprises the eastern half of the Sacramento and San Joaquin Valleys, including all counties not included in districts 1½, 1¾, 2, 2½, 3, 4, 4½, and 4¾.

District 1½ comprises the counties of Del Norte and Humboldt, and that part of Siskiyou west of Southern Pacific Railroad and Klamath River.

District 1¾ comprises Modoc and Lassen Counties, and Siskiyou County east of Southern Pacific Railroad and Klamath River.

District 2 comprises that part of State south of Humboldt and Tehama Counties, west of Sacramento River and north of San Francisco Bay, in-

Open seasons—Continued.	Dates inclusive
Cottontail and brush rabbits, ¹⁴ mountain, valley, and desert quail (see exceptions)....	Dec. 1-Dec. 31.
Exceptions: Rabbits in district 4¾.....	No close season.
Mountain and valley quail, district 1½.....	Nov. 1-Dec. 31.
Grouse.....	Sept. 15-Oct. 14.
Dove (see exception).....	Sept. 1-Sept. 30.
Exception: In districts 4, 4½, and 4¾.....	Sept. 1-Oct. 31.
Sage hen.....	Aug. 1-Aug. 15.
Duck, goose, brant, Wilson's snipe or jacksnipe, coot (mud hen).....	Oct. 1-Jan. 15. ¹⁵
Gallinule.....	Oct. 1-Nov. 30.

No open season: Does, spike bucks, fawns, elk, antelope, mountain sheep; tree squirrels; sierra hares; pheasants, introduced quail or partridges, turkeys, rail, plovers, yellowlegs, swans, wood duck, elder ducks, auklets, bittern, little brown, sand-hill, and whooping cranes, fulmars, grebes, guillemots, gulls, herons, jaegers, loons, murre, petrels, band-tailed pigeons, puffins, shearwaters, terns, and all shore birds (except Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Game: Nonresident, \$10; alien, \$25 (except those with first papers, fee \$10); fish: Nonresident, \$3; alien, \$5; resident: Game, \$2 (resident, under 18, \$1); fish, \$2. Fishing license not required of persons under 18 years of age. To veterans of the Civil War, issued free of charge. Issued by commissioners and county clerks. Unlawful to hunt on posted lands of another without permission of owner. Deer-tag license, \$1; commercial club, citizen owner, \$25; alien owner, \$100; citizen operator, \$5; alien operator, \$25.

Bag limits and possession: Two deer a season (except in district 1¾, one only); 15 cottontail or brush rabbits a day, 30 a week; 4 grouse a day,

cluding counties of Glenn, Colusa, Yolo, Solano, Napa, Lake, Sonoma, and Marin, and that portion of Mendocino County not included in district 2½.

District 2½ comprises townships in Mendocino County bordering on Pacific Ocean (except township 11 north, ranges 15 and 16 west) and townships 13, 14, 15, 16, 17, and 18 north, range 16 west.

District 3 comprises region around southern portion of San Francisco Bay and coast counties south of the Golden Gate as far as Ventura, including counties of Contra Costa, Alameda, San Mateo, Santa Clara, San Francisco, Santa Cruz, Monterey, San Luis Obispo, Santa Barbara, and Ventura; also San Benito and western half of San Joaquin, Stanislaus, Merced, Fresno, Kings, and Kern Counties.

District 4 comprises counties in southern California, namely, Los Angeles, Orange, Riverside, and San Bernardino.

District 4½ comprises counties of Mono and Inyo. District 4¾ comprises San Diego and Imperial Counties.

Districts 23, 24, 25, and 26, all located in district 1, are as follows:

District 23 comprises drainage area of Lake Tahoe and Truckee River and head waters of Rubicon and American Rivers, in counties of Placer and Eldorado.

District 24 comprises drainage area of Silver, Twin, Blue, Meadow, and Wood Lakes in counties of Alpine and Amador.

District 25 comprises drainage area of Lake Almanor in counties of Plumas and Lassen.

District 26 comprises Sixty Lake Basin, part of Rae Lake, and to south fork of Woods Creek in Fresno County.

¹⁴ Owner or tenant, or person holding written permission from owner or tenant, may kill rabbits on own premises at any time, but rabbits killed in close season may not be shipped or sold.

¹⁵ Waterfowl in districts 4, 4½, 4a, 4e, 19, 20, 20a, 21, and 22 may be hunted only on Wednesdays, Saturdays, Sundays, legal holidays, and opening and closing days of season, and in district 4a waterfowl may not be hunted on said days before 8 a. m.

8 a week; 4 sage hens a day, 8 a week; 10 mountain quail a day, 20 a week; 15 valley or desert quail a day, 30 a week; 20 Wilson's snipe or jacksnipe a day, 50 a week; 15 mourning doves a day, 30 a week; 15 ducks a day; 4 geese (honkers) a day; 8 brant a day, 24 a week; 25 coots (mud hens), but not more than 15 gallinules a day, 50 mud hens a week.

Possession in excess of daily limit prohibited, except that not more than 25 wild ducks and 8 wild geese may be possessed at any one time. Persons killing deer must retain in possession during open season and 10 days thereafter skin and portion of head bearing horns. One day's limit of game birds or animals may be possessed during first 5 days of close season.

Interstate transportation: Export of all protected game prohibited. All shipment by parcel post prohibited.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of deer meat and hides, tree squirrels, and game birds prohibited. Hides of deer taken in a foreign country and cottontail and brush rabbits taken during open season may be sold.

COLORADO

Open seasons: ¹⁶	Dates inclusive
Deer (having horns with two or more prongs on each horn)...	Oct. 12-Oct. 15.
Rabbit, hare.....	No close season.
Duck, goose, brant, coot, Wilson's snipe or jacksnipe.....	Sept. 16-Dec. 31.
Sora and other rails and gallinule (except coot).....	Sept. 1-Nov. 30.

No open season: Elk, antelope, mountain sheep, does, fawns, Abert's, black or tuft-eared squirrels, prairie chickens, mountain and willow grouse, sage chickens (1932), quail (bob white and crested), pheasants, ¹⁷ doves; partridges, ptarmigan, wild turkeys, swans, wood duck, elder ducks, bitterns, little brown, sandhill, and whooping cranes, grebes, gulls, herons, jaegers, loons, band-tailed pigeons, terns, and all shore birds (except Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident: Big game, \$25; small game, \$5; fish, \$3. Resident: Big game, \$5; small game and fish, \$2. No person under 18 is permitted to hunt big game. Fishing license not required of boys under 16 or of women. Children under 12 not permitted to hunt except on own premises or those of parent or guardian. Guide, \$5, in addition to hunting license. Issued by commissioner, county clerks, and other agents. Unlawful to hunt in any inclosure not public land without consent of owner. Unlawful to shoot game from public highway.

Unnaturalized foreign-born residents not permitted to hunt or to own or possess shotgun, rifle, or pistol.

Bag limits and possession: One deer a season, coupon required; 15 ducks, 4 geese, 8 brant, 15 Wilson's snipe, 25 sora, 15 in all of other rails, coots and gallinules a day or in possession, except that not more than 25 ducks and 8 geese may be possessed at any one time. Persons under 12 years of age limited to half this number of birds. Possession permitted during first 5 days of close season. Commissioner may issue permit authorizing storage, possession, and use of game for 90 days after close of open season (except possession of migratory birds limited to 10 days after close of season.)

Interstate transportation: Export of all protected game is prohibited; provided, game in not exceeding the numbers allowed in possession, may be exported under permit from game commissioner (fee, 25 cents for each bird) if permit be attached and packages plainly marked so as to show nature of contents, but not more than two days' limit of migratory birds shall be exported

in any one calendar week; edible portion of deer may be exported under \$5 permit from the commissioner.

Game taken outside of State and legally exported may be possessed at any time, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season. Importer must obtain from State game and fish commissioner a certificate, fee \$1, to import game.

Sale: Sale of all game taken in State prohibited, but game (except migratory birds) coming from without State may be sold under importer's license by indorsement of shipping invoice to purchaser.

CONNECTICUT

Open seasons: ¹⁸	Dates inclusive
Hare, rabbit (except European, Belgian, or German hare and jack rabbit, no close season)...	Nov. 1-Dec. 15.
Gray squirrel.....	Oct. 8-Nov. 23.
Partridge or ruffed grouse, Mongolian, Chinese, or English pheasant (male).....	Oct. 20-Nov. 23.
Woodcock.....	Oct. 20-Nov. 19.
Duck, goose, brant, coot (mudhen), Wilson's or English snipe.....	Oct. 1-Jan. 15.
Rail and gallinule, other than coot.....	Sept. 1-Nov. 30.

No open season: Deer, ¹⁹ quail (October 8, 1931), Hungarian partridges (October 21, 1931); pheasant hens, doves, swans, wood duck, elder ducks, auks, bitterns, fulmars, gannets, grebes, guillemots, gulls, herons, jaegers, loons, murres, petrels, shearwaters, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident: Game, \$10.35; game and fish, \$14.35; fish, \$5.35; resident of State charging fee in excess of \$5.35 pays same fee in Connecticut. Resident citizen: Game, \$3.35; game and fish, \$5.35; fish, \$3.35. Issued by city, town, or borough clerk. Hunting license not issued to persons under 16, and fishing license not required of such persons. Resident and his children may hunt or fish during open season without license on land on which he is actually domiciled, if such land is not used for club, shooting, or fishing purposes. Licensee must report amount of game killed, and must wear license button on outer garment. Alien: Not permitted to hunt; fish, \$5.35. Taxidermist, \$5. Nonresident or alien who owns real estate assessed at not less than \$500, or lineal descendant of such nonresident or alien, pays same fee as resident for fishing license.

Bag limits and possession: Five gray squirrels a day, 30 a season; 3 hares or rabbits a day, 30 a season; 2 ruffed grouse a day, 15 a season; 2 pheasants a day, 15 a season; 15 ducks, 4 geese, 8 brant, 4 woodcock a day; 20 Wilson's snipe, 25 coot, 25 sora, and 25 of all other rails and gallinules, but not more than 15 of any one species a day. Possession of more than daily bag limit of game prima facie evidence of violation, but not more than 30 ducks and 8 geese may be possessed at any one time. Resident may possess during first 10 days of close season, for his own use and not for sale, game lawfully taken.

Interstate transportation: Export of all protected game prohibited, provided a licensee under permit may export game lawfully killed and possessed, when tagged to show name, address, and license number of shipper, if not for sale; but not more than two days' limit of migratory birds may be exported in any one calendar week.

Game taken outside of State and legally exported may be possessed at any time, except that migratory game birds may be possessed only during

¹⁸ Connecticut: Governor may suspend open seasons during time of drought, and on recommendation of board of fisheries and game may close season on partridge or ruffed grouse during 1930.

¹⁹ Owners of agricultural lands, member of family, or employee may kill deer with a shotgun or, under permit, with a rifle, at any time on such lands when deer are damaging fruit trees or growing crops, but such killing or wounding must be reported to the board of fisheries and game within 12 hours.

¹⁶ Colorado: Game and fish commissioner, on petition of board of county commissioners, may suspend or shorten seasons on game in any county or under justifiable conditions may lengthen them.

¹⁷ Pheasants damaging crops may be killed or trapped under permit of commissioner.

open season where taken and first 10 days of close season. Importer must obtain from superintendent of fisheries and game a permit to import game. **Sale:** Sale of all protected game prohibited, except game (other than migratory game birds) legally taken and transported from a State or country that does not prohibit sale or exportation of such game may be bought or sold under regulations of board of fisheries and game.

DELAWARE

Open seasons: ²⁰	Dates inclusive
Rabbit, hare, quail, partridge...	Nov. 15-Dec. 31.
Squirrel (fox, black, gray).....	Sept. 1-Oct. 15.
Dove (see exception).....	Sept. 1-Dec. 15.
<i>Exception: In New Castle County.....</i>	
Woodcock.....	Sept. 1-Dec. 1.
Duck, goose, brant, Wilson's snipe or jacksnipe, coot.....	Nov. 15-Dec. 15.
Rail and gallinule other than coot.....	Oct. 16-Jan. 31.
	Sept. 1-Nov. 30.

No open season: Hungarian partridges or pheasants, swans, wood duck, eider ducks, reedbirds, bitterns, sand-hill cranes, grebes, gulls, herons, loons, murre, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident: Game, \$15.50; fish, \$5 (not required in Delaware River or Bay). Resident: Game and fish, \$1.10 (required outside county of residence). Issued by commission. Resident landowner may hunt or fish during open season on own land without license. Unlawful to hunt on land of another without permission from owner or occupant. Fishing license not required of certain excursionists. Nonresidents who own or lease property at seaside summer resorts and their relatives, friends, and patrons sojourning at such resorts may fish for nongame fish and hunt on shores of such resorts without license during open season, between June 1 and September 30. Nonresident licensees must wear license-plate or button on outer garment.

Bag limits and possession: Six in all of rabbits, hares, and squirrels, 15 ducks, 4 geese, 8 brant, 20 Wilson's snipe, 4 woodcock, 25 coots, 25 sora, 25 in all of other rails and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules, and not more than 50 in all of sora and other rails combined; 12 birds of any other species a day. Possession of migratory birds permitted during first 10 days of close season, but not more than 30 ducks and 8 geese may be possessed at any one time; other game during first 5 days thereof.

Interstate transportation: Licensees may carry or ship openly within or out of State in any one week not more than 10 rabbits, 10 squirrels, 50 rails, and 20 birds or fowls of any other species legally killed, but not more than 8 geese, 16 brant, or 8 woodcock may be shipped or transported in one week.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of all protected game prohibited, provided a resident may sell in his own county 20 rabbits a season, lawfully taken by him. Rabbits coming from without State may be sold from November 15 to December 31.

DISTRICT OF COLUMBIA ²¹

Open seasons:	Dates inclusive
Deer meat (sale or possession)...	Sept. 1-Jan. 1.
Rabbit (except English rabbit, Belgian hare), squirrel (sale or possession).....	Nov. 1-Feb. 1.
Marsh blackbird.....	Sept. 1-Feb. 1.

²⁰ Delaware: Minors under 15 are not permitted to hunt game with shotgun or rifle unless accompanied by an adult lawfully hunting.

²¹ District of Columbia: Hunting prohibited in District by act of June 30, 1906, except on marshes of Eastern Branch above Anacostia Bridge and below Aqueduct Bridge on Virginia side of Potomac, but in these areas no birds may be shot within 200 yards of any bridge or dwelling.

Open seasons—Continued. Dates inclusive

Duck, goose, brant, Wilson's snipe, coot.....	Nov. 1-Jan. 31.
Woodcock.....	Nov. 10-Dec. 10.
Rail and gallinule.....	Sept. 1-Nov. 30.

No open season: Doves, swans, wood duck, reedbirds, bitterns, grebes, gulls, herons, loons, murre, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Bag limits and possession: Fifteen ducks, 4 geese, 8 brant, 20 Wilson's snipe, 4 woodcock, 25 coots, 25 sora, 25 in all of other rails and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules a day. Not more than 30 ducks and 8 geese may be possessed. Possession of migratory birds permitted during first 10 days of close season; quail, November 1 to March 15; ruffed grouse or pheasant (except English or other imported pheasants raised in inclosures, possession unrestricted), and wild turkey, November 1 to December 25; prairie chicken (pinnated grouse), September 1 to March 15.

Interstate transportation: Export of migratory game birds in excess of two days' bag limit in any one calendar week prohibited.

Migratory game birds taken outside of District and legally exported may be possessed during open season where taken and first 10 days of close season. Other game may be possessed during open season in District.

Sale: Sale of all game birds prohibited. Deer, rabbit, and squirrel may be sold during open season.

FLORIDA

Open seasons: ²²	Dates inclusive
Deer (male) (see exception).....	Nov. 20-Dec. 31.
<i>Exception: In Collier County.....</i>	
Cat squirrel, wild turkey, quail (see exceptions).....	Nov. 20-Feb. 15.
<i>Exceptions: Wild turkey, in Collier County.....</i>	
Quail, in Collier County.....	July 1, 1934.
Duck, ²² goose, brant, Wilson's snipe or jacksnipe, coot, dove ²² (see exception).....	Nov. 20-Jan. 31.
<i>Exception: Dove, in Dade, Monroe, and Broward Counties.....</i>	
Rail or marsh hen, other than coot and gallinule.....	Sept. 16-Nov. 15.

	Sept. 15-Nov. 30.
Gallinule.....	Nov. 20-Nov. 30.

No open season: Does, gray, black, or fox squirrels (1932); ruffed grouse, introduced pheasants, and other foreign game birds; swans, wood duck, reedbirds, bitterns, sand-hill and whooping cranes, gannets, grebes, gulls, herons, jagers, loons, petrels, shearwaters, terns, woodcock, and all shore birds (except Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident: Game, \$25.50 (State); fresh-water fish, \$10.50 (State), \$3.25 (county license). Resident: Game, \$8 (State); \$3.25 (county other than county of residence), \$1.25 (county of residence); fresh-water fish, \$3.25 (not required in county of residence), \$1.25 (county other than county of residence). Duplicate license, fee 25 cents. Issued by county judge. License not required of person under 15, nor of resident Confederate veteran who is entitled to State pension, nor of landowner or member of his family in county of residence on own land or that of parent, wife, or child; nor of resident over 65. Guide, \$10, alien, \$50; issued by State game commissioner. Boats (renting for hunting or fishing): Under 18 feet in length, \$2.50 each; 18 to 21 feet, \$4 each; 21 to 25 feet, \$15 each; over 25 feet, \$25 each; issued by State game commissioner. Licensee must report to State game commissioner number and kind of game taken.

Bag limits and possession: One deer a day, 2 a season; 2 turkeys a day, 5 a season; 200 of any

²² Florida: State game commissioner on request of county commissioners may extend State seasons on ducks and mourning doves to full period allowed by Federal regulations.

²³ Ducks may be taken on Iamonia, Jackson, and Micoosukee Lakes in Leon and Jefferson Counties only on Monday, Wednesday, and Friday of each week during open season.

other species of game birds or animals a season; 15 cat squirrels, 15 quail, 25 doves, 15 ducks, 4 geese, 5 brant, 15 Wilson's snipe, 20 coots, and 25 in all of rails and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules, a day. Game lawfully taken may be possessed during the open season and first 5 days of close season, but not more than two days' limit of game may be in possession at one time.

Interstate transportation: Export of all protected game prohibited, except nonresident licensee may export game lawfully taken by himself but not to exceed 2 deer and 5 turkeys a season nor more than two days' limit of other game during any one calendar week.

Sale: Sale of all game prohibited, except that reindeer meat may be brought into State and sold under permit from State game commissioner.

GEORGIA

Open seasons:	Dates inclusive
Deer (male with exposed horns) (see exception).....	Nov. 1-Dec. 31. ²⁴
<i>Exception:</i> In Catoosa, Chattooga, Dade, Dawson, Fannin, Gilmer, Gordon, Habersham, Lumpkin, Murray, Pickens, Rabun, Stephens, Towns, Union, Walker, White, and Whitfield Counties.....	
Bear.....	No open season.
Rabbit.....	Nov. 20-Feb. 28.
Cat squirrel, quail, ²⁵ partridge, wild turkey.....	No close season.
Opossum.....	Nov. 20-Mar. 1.
Dove.....	Oct. 1-Feb. 1.
Duck, goose, brant, coot, Wilson's snipe.....	Sept. 1-Sept. 30.
Woodcock.....	Nov. 20-Jan. 31.
Rail (marsh hen) and gallinule, other than coot.....	Nov. 1-Jan. 31.
	Oct. 1-Dec. 31.
	Sept. 1-Nov. 30.

No open season: Does and fawns, fox squirrels, grouse, pheasants, introduced game birds, swans, wood duck, eider ducks, reedbirds, bitterns, sandhill and whooping cranes, gannets, grebes, gulls, herons, loons, petrels, shearwaters, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting licenses: Nonresident, \$25; resident, State, \$3; county, \$1 (good only in county of residence). License not required of landowners or tenants and their families with consent of landowner to hunt on own land. Issued by commissioner or county warden.

Bag limits and possession: Two deer, 2 turkeys a season, 15 cat squirrels, 20 quail, 15 ducks, 4 geese, 8 brant, 20 Wilson's snipe, 4 woodcock, 25 coots, 25 sora, and 25 in all of other rails and gallinules, but not more than 15 of any one species; 25 doves a day. Possession of migratory birds, except woodcock, permitted during first 10 days of close season but not more than 30 ducks and 8 geese may be possessed at any one time.

Interstate transportation: Export of all protected game prohibited; provided nonresident licensee may take out in personal possession game lawfully killed, but not more than two days' limit of migratory birds may be exported in any one calendar week.

Game taken outside of State and legally exported may be imported and possessed under a permit, in like manner as game taken in State. Permits issued by game and fish commissioner.

Sale: Sale of reedbirds (ricebirds) and all protected game prohibited.

²⁴ Georgia: Killing of a deer must be reported to warden of county in which killed or to commissioner of game and fish at Atlanta within 5 days.

²⁵ Quail in Pierce County may be hunted only on Tuesday and Friday of each week.

HAWAII

Open seasons:	Dates inclusive
Deer.....	Apr. 1-Oct. 31.
Quail (except bobwhite) in Maui County.....	Nov. 1-Jan. 31.
In Hawaii County.....	Dec. 1-Jan. 31.
In Kauai County, and city and county of Honolulu.....	No open season.
Pheasant (male) in Maui, Kauai, and Honolulu Counties.....	Nov. 1-Jan. 31.
In Hawaii County.....	Dec. 1, Jan. 31.
Wild dove, wild pigeon in Honolulu ²⁶ County.....	Sept. 1-Dec. 31.
In Hawaii County.....	July 1-Jan. 31.
In Maui and Kauai Counties.....	July 1-Dec. 31.
No open season: Wild ducks and geese, shore birds, wild peacock, and blue-eyed, top-knot, bar-shouldered, green-winged, and bronze-winged doves, except as permitted by board, hen pheasants, wild African ringneck doves, chachalacas, curassows, guans, guinea fowl, bobwhite quail; quail in Kauai and Honolulu Counties.	
Hunting and fishing licenses: County licenses: Nonresident citizen or declarant alien: Game, \$10; fish, \$2.50; resident citizen: Game, \$5; fish, \$2.50. Alien: Game, \$25; fish, \$5. Hunting and fishing licenses issued by county treasurer. Permission of owner or occupant required to hunt on lands of another.	
Bag limits and possession: <i>Hawaii County:</i> Cock pheasants, 5 a day, 25 a season; quail, 15 a day, 30 in 7 consecutive days; doves and pigeons, 20 a day, 50 in 7 consecutive days. <i>Honolulu County:</i> Cock pheasants, 3 a day; doves and pigeons, 20 a day. <i>Kauai County:</i> Cock pheasants, 3 a day; doves and pigeons, 15 a day. <i>Maui County:</i> Cock pheasants, 5 a day, 10 in 7 consecutive days; quail, 10 a day, 25 in 7 consecutive days; doves and pigeons, 15 a day, 45 in 7 consecutive days.	

IDAHO

Open seasons: ²⁷	Dates inclusive
Elk, in Clearwater and Idaho Counties.....	Oct. 1-Nov. 15.
In Franklin County.....	Oct. 20-Oct. 30.
In Clark, Fremont, Jefferson, Madison, and Teton Counties.....	Dec. 1-Dec. 15.
Deer, mountain goat, in Adams, Blaine, Boise, Butte, Custer, Elmore, Lemhi, and Valley Counties, and in Idaho County south of Main Salmon and east of Little Salmon.....	Oct. 6-Oct. 31.
In remainder of Idaho County.....	Oct. 1-Nov. 15.
In Clearwater County north and west of North Fork and Little North Fork Clearwater River.....	Oct. 15-Nov. 30.
In rest of Clearwater County.....	Oct. 1-Nov. 15.
Deer, in Clark, Fremont, Jefferson, Madison, and Teton Counties.....	Oct. 11-Oct. 20.
In Gem County.....	Oct. 6-Oct. 31.
In Benewah, Bonner, Boundary, Kootenai, Latah, Lewis, Nez Perce, and Shoshone Counties.....	Nov. 1-Nov. 30.
In Bannock, Bear Lake, Carbou, Franklin, Oneida, Power, and Twin Falls Counties.....	Oct. 20-Oct. 30.

²⁶ Hawaii: Hunting prohibited in city and county of Honolulu except on Saturdays, Sundays, and legal Territorial holidays.

²⁷ Idaho: State game warden may close season in any county or part thereof on any species of game or fish threatened with extinction.

Open seasons—Continued.

	<i>Dates inclusive</i>
In Washington County.....	Oct. 1-Oct. 31.
Mountain sheep (ram only—see special license) in Valley and Lemhi Counties.....	Oct. 15-Oct. 25.
Bear (see exception).....	No close season.
<i>Exception:</i> In Benewah, Bonner, Boundary, Clearwater, Kootenai, Latah, Lewis, Nez Perce, and Shoshone Counties.....	Sept. 1-May 31.
Chinese, ring-necked, or Mongolian pheasant, in Ada, Adams, Blaine, Canyon, Cassia, Elmore, Gem, Gooding, Jerome, Lincoln, Minidoka, Owyhee, Payette, Twin Falls, and Washington Counties.....	Oct. 15-Nov. 25.
In Bannock, Bingham, Bonneville, Fremont, Jefferson, and Madison Counties, and Power County north and west of Snake River.....	Nov. 1-Nov. 15.
In Clearwater, Idaho, Latah, Lewis, and Nez Perce Counties.....	Nov. 1-Nov. 30.
Ruffed grouse, native pheasant, blue grouse, in Adams, Blaine, Boise, Cassia, Elmore, Gem, Gooding, Jerome, Lincoln, Minidoka, Owyhee, Twin Falls, Valley, and Washington Counties.....	Aug. 10-Aug. 20.
In Bannock, Bear Lake, Bingham, Bonneville, Butte, Caribou, Clark, Franklin, Fremont, Jefferson, Lemhi, Madison, Oneida, Power, and Teton Counties.....	Aug. 24-Sept. 1.
In Clearwater, Idaho, Lewis, and Nez Perce Counties.....	Sept. 1-Sept. 20.
In Boundary, Bonner, Kootenai, and Shoshone Counties	Oct. 1-Oct. 15.
Sharp-tailed grouse, in Adams, Blaine, Boise, Camas, Cassia, Elmore, Gem, Gooding, Jerome, Lincoln, Minidoka, Owyhee, Twin Falls, Valley, and Washington Counties.....	Aug. 10-Aug. 20.
In Bannock, Bear Lake, Caribou, Franklin, Oneida, and Power Counties.....	Aug. 24-Sept. 1.
Sage hen or sage grouse, in Adams, Blaine, Boise, Butte, Camas, Cassia, Custer, Elmore, Gem, Gooding, Jerome, Lemhi, Lincoln, Minidoka, Twin Falls, Valley, and Washington Counties.....	Aug. 10-Aug. 20.
In Bannock, Bear Lake, Bingham, Bonneville, Caribou, Clark, Franklin, Fremont, Jefferson, Madison, Power, and Teton Counties.....	Aug. 20-Sept. 1.
Hungarian partridge, in Benewah, Bonner, Boundary, and Kootenai Counties.....	Nov. 1-Nov. 15.
In Clearwater, Idaho, Latah, Lewis, and Nez Perce Counties.....	Nov. 1-Nov. 30.
Quail, in Lemhi County.....	Oct. 20-Oct. 31.
In Ada, Canyon, Gem, Nez Perce, Payette, Twin Falls, and Washington Counties.....	Nov. 1-Nov. 15.
Dove.....	Sept. 1-Dec. 15.
Duck, goose, brant, Wilson's snipe or jacksnipe, coot (see exceptions).....	Oct. 1-Jan. 15.
<i>Exception:</i> In Boundary, Bonner, Kootenai, Benewah, and Shoshone Counties.....	Sept. 16-Dec. 31.
Rail and gallinule, other than coot.....	Sept. 1-Nov. 30.
No open season: Deer, elk, mountain goats, mountain sheep (except as above); moose, antelope,	

caribou, buffalo, spotted fawns, calf elk; quail, grouse (except as above), imported pheasants (except Chinese, ring-necked, or Mongolian pheasants as above); prairie chickens, swans, wood duck, bitterns, little brown and sand-hill cranes, grebes, gulls, herons, loons, terns, and all shore birds (except Wilson's snipe or jack-snipe).

Hunting and fishing licenses: Nonresident: Game and fish, \$50; bird, \$10; fish, \$5. Alien: Game and fish, \$75; fish, \$10; gun license, \$5. Resident: Game and fish, \$2. Special licenses for mountain sheep in Valley and Lemhi Counties: Nonresident, \$50; resident, \$25. Issued by warden, deputy, or authorized agent. Fishing license not required of minors under 14 years of age; and veterans of Civil War may hunt and fish without a license. Persons under 12 prohibited from possessing gun afield. Taxidermist, \$10.

Bag limits and possession: One deer, 1 elk, 1 mountain goat, 1 mountain sheep a season; 6 quail, 4 in all of Chinese, ring-necked or Mongolian pheasants; 8 Hungarian partridges, 4 sage hens, native pheasants, or grouse, 12 ducks, 4 geese, 4 brant a day, or in possession 25 doves, 20 Wilson's snipe, 25 coots, 25 sora and 25 in all of other rails and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules a day. Migratory waterfowl may be stored by owner, under affidavit and storage permit, during open season and 10 days thereafter. Game animals may not be shipped, transported, or carried more than 5 days after close of open season.

Interstate transportation: Export of all protected game prohibited, provided a hunter may export under hunting-license coupon, big game lawfully taken; and one day's limit of game birds may be transported in personal possession but may not be shipped or mailed. Big game once shipped within State may be exported under a 50-cent permit obtained from game warden or deputy. Mounted heads and stuffed birds legally obtained may be exported under a reshipping permit. Shipment of game by parcel post prohibited.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State, if identification tags or shipping or possession permits are attached.

Sale: Sale of all protected game prohibited. Hides, heads, and horns may be sold under permit.

ILLINOIS

Open seasons:	<i>Dates inclusive</i>
Rabbit.....	Nov. 10-Jan. 31.
Squirrel, in northern zone.....	Sept. 1-Dec. 1.
In central zone.....	Aug. 1-Dec. 1.
In southern zone.....	July 1-Dec. 1.
Quail (bobwhite).....	Nov. 10-Dec. 10.
Prairie chicken.....	Nov. 10-Nov. 15.
Introduced pheasant (cocks).....	Nov. 10-Nov. 15.
Dove.....	Sept. 1-Sept. 30.
Duck (except wood duck), goose, brant, coot.....	Sept. 24-Jan. 7.
Wilson's snipe or jacksnipe.....	Sept. 24-Dec. 31.
Rail and gallinule, other than coot.....	Sept. 16-Nov. 30.
No open season: Deer (1939); wild turkeys, introduced pheasant hens, and grouse, ruffed grouse (partridge), blue, mountain, and valley quail, Hungarian partridges, capercaillie, heath hens, black grouse, woodcock, 1931; swans, wood duck, elder ducks, bitterns, little brown, sand-hill, and whooping cranes, grebes, gulls, herons, jaegers, loons, murrelets, petrels, terns, and all shore birds (except Wilson's snipe or jacksnipe).	
Hunting and fishing licenses: Nonresident citizen: Game, \$15.50; fish, \$3; resident citizen: Game, \$1 fish, 50 cents. Hunting licenses not issued to aliens, nor to minors under 16 without written consent of parent or guardian. Issued	

²⁵ *Illinois:* Southern zone includes Madison, Bond, Fayette, Effingham, Jasper, Crawford, and all counties south. Central zone includes Hancock, McDonough, Fulton, Tazewell, McLean, Ford, Vermilion, and all counties south to northern boundary of southern zone. Northern zone includes rest of counties of State.

by village, county, or city clerk. Hunting club, \$10, issued by department of conservation. Fishing license not required of persons under 21. Owners, their children, and tenants in actual residence may hunt or fish with hook and line during open season on own land without license. Permission required to hunt on lands of another. Taxidermist, \$5.

Bag limits and possession: Ten squirrels, 15 rabbits, 12 quail, 3 prairie chickens, 2 cock pheasants, 15 doves, 15 snipe, 15 in all of coots and gallinules, 15 rails but not more than 25 in all of rails, coots, and gallinules; 15 ducks, 4 geese, 4 brant a day. Limit, in possession, 20 squirrels, 36 quail, 9 prairie chickens, 6 cock pheasants, 25 doves, 50 snipe, 60 coots and gallinules, 60 rails, 30 ducks, 8 geese, 10 brant.

Interstate transportation: Export of all protected game (except rabbit) prohibited; provided, nonresident licensee may take from State 50 game birds or animals, if carried openly for inspection, but not more than two days' limit of migratory birds may be exported in any one calendar week. Resident may carry out game under his license.

Deer lawfully killed and shipped may be brought or shipped into State, and rabbits may be imported November 10 to February 5.

Sale: Sale of all protected game (except rabbit, November 10-February 5) prohibited.

INDIANA

Open seasons:	Dates inclusive
Rabbit.....	Oct. 1-Jan. 10.
Squirrel (except red squirrel, no close season).....	Aug. 1-Oct. 31.
Quail, ruffed grouse.....	Nov. 10-Dec. 20.
Prairie chicken.....	Oct. 15-Oct. 31.
Duck, goose, brant, Wilson's snipe or jacksnipe, coot.....	Oct. 1-Jan. 15.
Woodcock.....	Oct. 15-Nov. 14.
Rail and gallinule, other than coot.....	Sept. 1-Nov. 30.

No open season: Deer, Hungarian partridges, introduced pheasants, wild turkeys, doves, swans, wood ducks, bitterns, sand-hill and whooping cranes, gannets, grebes, gulls, herons, jaegers, loons, murrets, petrels, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident: Game, fish, and trapping, \$15.50; fish, \$2.25. Resident: Game, fish, and trapping, \$1. Issued by clerk circuit court and by superintendent and his agents. Permits to hunt and fish without license issued free to honorably discharged soldiers, sailors, and marines who are residents of State; resident owners of farm land, their children living with them, and tenants residing thereon may hunt during open season on own land without a license. No license required of persons to fish in county of residence. All persons under 18 may fish without license. Permission required to hunt on lands of another.

Bag limits and possession: Ten rabbits, 5 squirrels (except red squirrels, no limit), 15 quail, 5 prairie chickens, 15 ducks, 4 geese, 6 brant a day; 20 Wilson's snipe, 4 woodcock, 25 coots, 25 sora, and 25 in all of other rails and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules a day. Not more than 18 woodcock, 30 ducks, 8 geese, or three days' limit of other migratory game birds may be possessed at one time by one person. Possession of migratory game birds permitted during first 10 days of close season.

Interstate transportation: Export of deer, quail, grouse, prairie chicken, pheasant, wild turkey, and migratory game birds prohibited, except any licensee may export 15 game birds in the aggregate of all kinds, lawfully taken by himself, each day he hunts in State, but not more than daily limit of any one species, and not more than 2 days' limit in any one calendar week, if carried openly for inspection together with his license or the package is tagged or clearly labeled with names and addresses of shipper and consignee and an accurate statement of number and kind of birds.

Deer, turkeys, and rabbits taken outside of State and legally exported may be possessed at any time; other game legally exported may be possessed in like manner as game taken in State.

Sale: Sale of squirrels (except red squirrels), quail, prairie chickens, introduced pheasants, Hungarian partridges, and migratory birds prohibited. Sale of rabbits prohibited during close season.

Miscellaneous: Shooting on highways or by aid of searchlight prohibited.

IOWA

Open seasons:	Dates inclusive
Squirrel.....	Oct. 1-Dec. 31.
Duck, goose, brant, Wilson's snipe or jacksnipe, coot.....	Sept. 16-Dec. 31.
Woodcock.....	Oct. 15-Nov. 14.
Rail and gallinule, other than coot.....	Sept. 16-Nov. 30.

No open season: Deer, introduced pheasants,²⁰ Hungarian partridges, quail, prairie chickens, ruffed grouse or pheasants, wild turkeys, turtle doves, swans, wood duck, elder ducks, bitterns, little brown, sand-hill, and whooping cranes, grebes, gulls, herons, jaegers, loons, murrets, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident or alien, game, \$15; fish, \$3. Resident citizen, game and fish, \$1. Issued by county recorder and authorized agents. Fishing license required of non-residents over 16 and resident males over 18 to fish in stocked waters. License not granted to persons under 18 without written consent of parent or guardian. Owners or tenants of farm lands and their wives or children may hunt and fish on own lands during open season without license. Unlawful to hunt on cultivated or inclosed lands of another without permission from owner.

Bag limits and possession: Fifteen squirrels a day or in possession; 15 ducks, 4 geese, 8 brant, a day, 21 waterfowl in possession, except that not more than 8 geese may be possessed at any one time; 15 Wilson's snipe, 4 woodcock, 15 each of rails, coots, and gallinules a day, but not more than 15 in all of rails and gallinules a day; 15 of each species in possession. Possession permitted during first 10 days of close season.

Interstate transportation: Export of all protected game prohibited, except that nonresident may take from State not more than 15 game birds or animals, if carried openly for inspection, and if hunting license be shown on request, but not more than 8 woodcock or 8 geese may be exported in any one calendar week.

Game taken outside of State and legally exported may be possessed at any time, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season. After expiration of first 10 days of close season in State, possessor of game must show lawful taking.

Sale: Sale of all protected game prohibited.

KANSAS

Open seasons: ²⁰	Dates inclusive
Fox squirrel.....	Aug. 1-Jan. 31.
Quail.....	Nov. 20-Nov. 30.
Prairie chicken (two days).....	Oct. 21 and 22. ²¹
Dove.....	Sept. 1-Oct. 15.
Duck, goose, brant, Wilson's snipe, coot.....	Sept. 16-Dec. 31.
Rail, other than coot and gallinule.....	Sept. 1-Nov. 30.
Gallinule.....	Sept. 16-Nov. 30.

No open season: Deer, antelope, red, gray, and black squirrels, ruffed grouse (partridges), pheasants (English, Mongolian, Hungarian); woodcock; swans, wood duck, elder ducks, bitterns, little brown, sand-hill, and whooping cranes, grebes, gulls, herons, loons, terns, upland plover,

²⁰ Iowa: Upon petition of 150 farmers and land-owners in any county who have suffered damage by Chinese, Mongolian, English, or ring-necked pheasants, State game warden may fix an open season for such county not exceeding 5 days during which a person may kill not exceeding 3 such pheasants a day but not more than 10 may be had in possession at any one time.

²⁰ Kansas: Seasons and bag limits may be shortened or reduced when deemed advisable by forestry, fish, and game commission.

²¹ Season on prairie chicken fixed by commission.

and all shore birds (except Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident: Game, \$15; fish, \$3. Hunting license issued by secretary of state and fishing license by county clerks. Resident: Game, \$1; fish, \$1. Issued by county clerk. Resident landowner or member of family may hunt or fish on own premises during open season without a license. Fishing license not required of males under 18, nor of women. Unlawful to hunt on land of another or on highway or railroad right of way adjacent thereto without consent of owner, unless accompanied by him.

Bag limits³⁰ and possession: Quail, 10 a day, 25 a season, 5 prairie chickens a day, 10 a season; 15 in all of ducks, Wilson's snipe, coots, and gallinules; 20 doves, 5 in all of geese and brant but not more than 4 geese, 6 rails, a day. Possession of two days' limit of two kinds of game permitted during first five days of close season, but not more than 30 ducks and 8 geese may be possessed at any one time.

Interstate transportation: Export of all protected game birds prohibited, except that a person under hunting license and affidavit of lawful killing and possession may ship to himself not more than two days' limit of two kinds of game taken by himself. Game of not more than two kinds, and not more than two days' bag limit, taken outside of State and legally exported may be possessed during open season and first five days of close season.

Sale: Sale of all protected game prohibited.

KENTUCKY

Open seasons:	Dates inclusive
Rabbit ³¹	Nov. 15-Dec. 31.
Squirrel.....	Aug. 1-Nov. 30.
Quail, ruffed grouse (native pheasant).....	Nov. 15-Jan. 1.
Dove.....	Sept. 1-Dec. 15.
Woodcock.....	Nov. 15-Dec. 15.
Duck, goose, brant.....	Nov. 1-Jan. 31.
Wilson's snipe or jacksnipe, coot.....	Nov. 1-Dec. 31.
Rail and gallinule, other than coot.....	Sept. 1-Nov. 30.

No open season: Deer, elk (1932); introduced pheasants, Hungarian partridges, wild turkeys (1932); swans, wood duck, bitterns, sand-hill and whooping cranes, grebes, gulls, herons, jaegers, loons, petrels, terns, and all shore birds (except woodcock and Wilson's snipe).

Hunting and fishing licenses: Nonresident or alien, game, \$10.50; fish, \$2.50. Resident, game, \$1; fish, \$1. Issued by county clerk. Resident landowner, tenant, and members of families may hunt on own land during open season without license. Unlawful to enter inclosed lands of another for shooting, hunting, or fishing without consent.

Bag limits and possession: Twelve squirrels a day, 24 in possession at one time; 12 quail a day, 12 in possession for each successive day of hunt; 15 doves a day, 15 in possession for each successive day of hunt; 2 ruffed grouse a day; 15 ducks, 4 geese, 8 brant, 4 woodcock, 20 Wilson's snipe, and 25 in all of rails, coots, and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules a day. Not more than 30 ducks and 8 geese may be possessed at any one time.

Interstate transportation: Export of deer, elk, and all game birds prohibited, except that a hunter may transport game lawfully killed and possessed by him, but not more than two days' limit of migratory birds may be exported in any one calendar week.

Game taken outside of State and legally exported may be possessed during open season in State in like manner as game taken in State.

Sale: Sale of quail, partridges, grouse, introduced or native pheasants, Hungarian partridges, wild turkeys, and migratory birds, wherever killed prohibited.

³⁰ See footnote on p. 17, col. 2.

³¹ Kentucky: Rabbits may be taken with dogs or traps (except snares) at any time for a person's own use on his own land, but not for sale or barter.

LOUISIANA

Open seasons:³² *Dates inclusive*

Deer, in Concordia, Avoyelles, Rapides, Vernon, and all parishes north thereof.....	Dec. 1-Jan. 15.
In parishes south.....	Nov. 1-Jan. 5.
Bear.....	Oct. 15-Jan. 5.
Squirrel, chipmunk.....	Oct. 1-Jan. 15.
Hare, rabbit.....	Oct. 1-Feb. 28.
Quail.....	Dec. 1-Feb. 15.
Wild turkey.....	Mar. 5-Apr. 5.
Woodcock.....	Dec. 1-Dec. 31.
Dove.....	Dec. 1-Jan. 31.
Duck, goose, brant, Wilson's snipe, rail, coot, gallinule.....	Nov. 1-Jan. 31.

No open season: Fawns, elk, prairie chickens, introduced pheasants, swans, wood duck, bobolinks, bitterns, sand-hill and whooping cranes, gannets, grebes, gulls, herons, loons, petrels, terns, upland plover (papabotte), and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident: Game animals and resident game birds, \$50; migratory game birds, \$25; fish, \$5. Resident, \$1. Club or association, \$5. Alien: General, \$50; game birds, \$25; fish, \$1. Issued by tax collectors. License does not authorize hunting on land of another without his written consent.

Bag limits and possession: Deer, bear, 1 each a day, 5 each a season; squirrels and chipmunks combined, 10 a day, 120 a season; 1 turkey a day, 5 a season; quail, 15 a day, 120 a season; dove, 25 a day, 300 a season; ducks, 15 a day, 300 a season; geese and brant combined, 8 a day, 100 a season but not more than 4 geese a day; Wilson's snipe, 20 a day, 240 a season; coots, 25 a day, 300 a season; sora, 25 a day, 300 a season; rails and gallinules combined, 25 a day but not more than 15 of any one species of rails (other than sora) and gallinules a day, 300 a season; woodcock, 4 a day, 22 a season.

The daily bag limits include all birds taken by guide or other person who for hire accompanies or assists a hunter in taking them. Game in excess of one day's limit in possession must be tagged. Possession of game birds permitted during first 10 days of close season, but not more than 30 ducks and 8 geese may be possessed at any one time.

Interstate transportation: Export of all protected game prohibited; provided a nonresident licensee may carry with him out of the State under his license and tag two days' limit of game birds, if not for sale. All game and all packages containing game must be tagged to show kind and number, names of consignor and consignee, initial point of billing, and destination.

Game taken outside of State and legally exported may be possessed at any time, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Sale: Sale of all game (except hares and rabbits during open season and 10 days thereafter) prohibited.

MAINE³⁴

Open seasons:	Dates inclusive
Deer (see exceptions).....	Oct. 16-Nov. 30.
Exceptions: In Androscoggin, Cumberland, Kennebec, Knox, Lincoln, Sagadahoc, Waldo, and York Counties.....	Nov. 1-Nov. 30.
In Hancock and Washington Counties.....	Nov. 1-Dec. 15.

³² Louisiana: Seasons on game may be curtailed in any parish by police juries with consent of commissioner.

³⁴ Maine: Commissioner may make local regulations restricting hunting, and governor may suspend hunting or fishing seasons during drought.

³⁵ All hunting is prohibited on Kineo Point and Mount Katahdin, Piscataquis County; on Prouts Neck, on Richmond Island, and locally on Cape Elizabeth and in town of Scarborough, Cumberland County; southern point Swan Island; Bartlett Island, Hancock County. (See State laws for details and other protected areas.)

Open seasons—Continued.	Dates inclusive
Hare, rabbit (see exception).....	Oct. 1-Mar. 31.
Exception: In Androscoggin, Cumberland, Sagadahoc, and York Counties.....	Oct. 1-Feb. 28.
Gray squirrel.....	Oct. 1-Oct. 31. ³⁰
Ruffed grouse, partridge, woodcock.....	Oct. 1-Oct. 31.
Duck, goose, brant, Wilson's snipe, coot (see exception). Exception: Waterfowl, in Back Bay, Portland, above Grand Trunk Railway bridge.....	Sept. 16-Dec. 31.
Rail, other than coot, and gallinule.....	No open season.
Gallinule.....	Sept. 2-Nov. 30.
	Sept. 16-Nov. 30.

No open season: Moose, caribou, Hungarian partridges, pheasants, black game, capercaillie, cock of the woods, doves, swans, wood duck, elder ducks, auks, bitterns, gannets, grebes, guillemots, gulls, herons, jaegers, loons, murrets, petrels, puffins, shearwaters, terns, and all shore birds (except woodcock and Wilson's snipe or jack-snipe).

Hunting and fishing licenses: Nonresident or alien: Big game, \$15.15; small game, \$5.15. Not issued to person under 18 without consent of parent or guardian. Holder of small-game license may exchange it for big-game license by paying difference in cost. Nonresident may not enter unorganized townships (except public camp sites maintained by Maine Forestry Department) May 1-Nov. 30 and kindle fires while camping, fishing, or hunting, or hunt in such territory during open season unless accompanied by registered guide. Nonresident fishing, \$3.15 for 30 days; \$5.15 for season. Aliens who pay taxes on real estate and who have resided in State two years continuously prior to application may obtain resident hunting and fishing licenses. Taxidermist: Resident citizen, \$5; resident alien, \$25. Guide licenses: Nonresident, \$20; resident, \$1. Must not guide more than five nonresidents hunting at one time. Sporting camp, \$5. Shipping licenses (within State): Resident, deer, \$2; one pair of game birds in seven days, 50 cents. Issued by commissioner.

Resident combination hunting and fishing, \$1.15; hunting, 65 cents; fishing, 65 cents. Resident or member of immediate family may hunt or fish without a license during open season on own land used exclusively for agricultural purposes and on which he is actually domiciled. License not required of resident under 18. Issued by city, town, and plantation clerks.

Bag limits and possession: One deer a season; 4 ruffed grouse a day, 25 a season; 10 ducks, 10 Wilson's snipe, 4 woodcock a day or in possession; 4 geese a day, 8 in possession; 8 brant a day or in possession; 25 sora, 25 in all of other rails, 25 coots and gallinules but not more than 15 of any one species of rails (other than sora) and gallinules a day. Transportation of migratory game birds must be completed within five days after close of season; reasonable time allowed after close of season to transport other game to home of owner. Deer or moose may not be used or had in possession in lumber camps. Deer must be transported open to view, tagged, and labeled with name and address of and be accompanied by owner. Resident may ship deer unaccompanied under special tag (fee, \$2). Possession of migratory birds limited to first 10 days of close season; deer legally procured may be possessed during close season.

Interstate transportation: Export of all protected game prohibited; provided, a resident of the State, under shipping license (fee, \$5) may export game birds lawfully killed by himself, but he must accompany the birds. A nonresident may export, open to view, 1 deer, 5 partridges, 10 ducks, 10 snipe, 4 woodcock and hares lawfully taken by himself, under hunting-license tags, when such tags bear written approval of a warden, deputy, or the commissioner. Nonresident

licensee may also ship out 1 pair of game birds a month under a special 50-cent license.

Moose or caribou, or parts thereof, taken outside of State and legally exported may be imported under license of commissioner for consumption or mounting, but not for sale. Deer properly tagged where taken and game birds may be imported under permit of commissioner and possessed in like manner as game killed in State. Permits and shipping tags issued by commissioner of inland fisheries and game.

Sale: Sale of all protected game birds prohibited; unlawful to sell, give away, or accept deer for export. Local provision dealer, under \$5 license, may purchase two deer for retail to his local customers. Deer skins and skins with heads attached may be bought and sold by residents under \$25 license. Heads, when detached from skins with which purchased, may be sold to licensed taxidermists.

MARYLAND

Open seasons: ³⁷	Dates inclusive
Deer (males having 6-inch antlers), in Allegany County, and within game reserves inclosed with 7-foot fence in Washington County.....	Dec. 1-Dec. 15.
In Garrett County.....	Dec. 1-Dec. 3.
Rabbit or hare, quail (partridge), ruffed grouse (pheasant), English or Mongolian pheasant, wild turkey (see exceptions).....	Nov. 10-Dec. 31.
Exceptions: Grouse, in Garrett County.....	Nov. 10-Dec. 1.
Wild turkey, quail, in Garrett County (1931).....	No open season.
Squirrel (see exceptions).....	{Sept. 1-Sept. 30. Nov. 10-Dec. 31.
Exceptions: In Allegany and Garrett Counties.....	Oct. 1-Nov. 9.
In Baltimore, Harford, and Howard Counties.....	Nov. 10-Dec. 31.
Raccoon, opossum.....	Nov. 2-Jan. 31. ³⁸
Woodcock.....	Nov. 10-Dec. 10.
Dove (see exceptions).....	{Sept. 1-Sept. 30. Nov. 10-Dec. 15.
Exceptions: In Baltimore, Harford, and Howard Counties.....	Nov. 10-Dec. 15.
In Allegany and Garrett Counties.....	Oct. 1-Nov. 9.
Duck, goose, brant, Wilson's snipe, coot.....	Nov. 1-Jan. 31. ³⁷
Rails and gallinules, other than coot.....	Sept. 1-Nov. 30.

No open season: Deer (except as above), elk (1931); Hungarian partridges, redbirds, swans, wood duck, elder ducks, auks, bitterns, sand-hill cranes, gannets, grebes, gulls, herons, jaegers, loons, murrets, petrels, shearwaters, terns, and all

³⁷ Maryland: Wild-fowl shooting restricted locally as follows: On the Susquehanna Flats south of a line from Concord Lighthouse, Harford County, and Carpenters Point, Cecil County, and north of a line extending from Turkey Point Lighthouse, Cecil County, and half a mile north of Spesutie Island to Oakington, Harford County, but at no time approaching within half a mile of northern end of Spesutie Island or adjacent mainland, hunting allowed only on Mondays, Wednesdays, and Fridays, Nov. 1-Dec. 31, and Mondays, Wednesdays, Fridays, and Saturdays, Jan. 1-31; in Kent County, on Chester River and tributaries, below Chester River bridge on Mondays and Fridays only Nov. 1-Dec. 31, except between Bay Bush Point on the Wieklife Farm and Durdings Creek, Mondays, Wednesdays, and Fridays during December; on Patuxent River and tributaries, and in St. Marys County on Wicomico River, Mondays, Wednesdays, Fridays, and Saturdays, Nov. 1-Dec. 31, but not restricted during January except by general provision prohibiting all hunting on Sunday.

³⁸ Unlawful to trap raccoon or opossum with steel trap or similar device, or without consent of owner, to cut trees in hunting them.

³⁰ Squirrels protected in parks and in compact or built-up portions of cities and villages.

shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident: Game, \$15.50 (fee, \$5.50 for State license if applicant owns real estate in Maryland assessed at \$500; \$1.50 for county license in county where such real estate is located); fish, \$5.50. Resident: Game, State, \$5.25; county, \$1.25; fish, \$1.25. Special license for fishing in Deep Creek Lake, Garrett County; resident of county, or person owning property within quarter of a mile of high-water mark of lake may fish in Deep Creek Lake without license; resident of State, nonresident of county, \$2.75; nonresident of State, \$5.25. Issued by clerks of circuit court of counties—in Baltimore City by clerk, court of common pleas. Permanent resident of Indianhead Government reservation may obtain a resident hunting license for Charles County. Hunting license not issued to persons under 14 without written request of parent or guardian. Angling license required above tidewater of person over 16. License not required of land-owners, tenants, and members of their families fishing from shore of own property. Hunting licensee required to wear tag displayed on middle of back and fishing-license button must be worn in plain view. Owners, tenants, and their children may hunt on own land during open season without license, except that waterfowl may not be hunted on waters of State without license. Local licenses issued to residents of Cecil and Harford Counties are valid for waterfowl hunting on Susquehanna Flats.

Sinkbox, sneak boat, blind, pusher: Sinkbox, \$20.75; sneak boat, \$5.75; issued by clerks circuit court of county of which applicant is a resident; booby, brush, or stake blind, \$5.50 (not issued except to resident of State or nonresident owner of land bordering on Potomac River or nonresident owner of land bordering on any waters of the State that is assessed at \$500 on tax books of Maryland); pushers, \$2.50; issued by clerks of circuit court of counties.

*Susquehanna Flats:*³⁷ Sinkbox, \$20.75; sneak boat, \$5.75; issued by clerks of circuit court in Cecil and Harford Counties.

Bag limits and possession: One deer a season; 1 wild turkey a day, 4 a season; 2 in all of English or Mongolian pheasants and ruffed grouse a day, 6 a season; 6 rabbits or hares, 10 squirrels, 10 quail (partridges), 4 woodcock, 25 doves, 20 jacksnipe, 25 coots, 25 in all of rails and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules, 15 ducks, 4 geese, 8 brant a day. Possession of waterfowl permitted during first 10 days of close season. Not more than 30 ducks and 8 geese may be possessed at any one time.

Interstate transportation: Export of all protected game (except waterfowl) prohibited; provided, a licensed hunter may take out under his license as personal baggage a quantity equal to two days' bag limit of game; provided further, no person may take or ship out more than 30 ducks, 8 geese, and 16 brant in any one calendar week. Waterfowl must be shipped open to view and tagged.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of quail, ruffed grouse, wild turkeys, or introduced pheasants (whether taken within or coming from without State), and doves and all other migratory game birds prohibited.

MASSACHUSETTS

Open seasons:³⁸

Deer (from half an hour before sunrise, first Monday in December to half an hour after sunset the second following Saturday, inclusive) (see exceptions)

Dates inclusive

Dec. 1-Dec. 6.

Exceptions: In Berkshire, Franklin Hampshire, and Hampden Counties.

Dec. 1-Dec. 13.

Open seasons—Continued.

Deer—Continued.

In Nantucket County..... No open season.

Hare (known as varying or Canada hare or snowshoe or white rabbit) or rabbit (see exception)..... Oct. 20-Feb. 15.

Exception: European hares, in Berkshire County..... No close season.

Gray squirrel, quail, male pheasant,⁴⁰ ruffed grouse (see exceptions)..... Oct. 20-Nov. 20.

Exceptions: Quail in Essex, Hampden, Hampshire, Middlesex, Nantucket, Norfolk, and Worcester Counties..... No open season.

Pheasant, ruffed grouse, in Dukes County..... No open season.

Pheasant in Nantucket County..... Oct. 20-Nov. 2.

Woodcock..... Oct. 20-Nov. 19.

Duck, goose, brant, Wilson's snipe, coot..... Oct. 1-Jan. 15.

Rail and gallinule, other than coot..... Oct. 1-Dec. 15.

No open season: Moose, doves, prairie chickens, Hungarian partridges, pheasant hens (English, golden, Mongolian),⁴⁰ heath hens, swans, wood duck, eider ducks, auks, bitterns, sand-hill and whooping cranes, fulmars, gannets, guillemots, gulls, herons, jaegers, loons, murre, terns, and all shore birds (except woodcock, and Wilson's snipe or jacksnipe).

Hunting and fishing⁴¹ licenses (Sporting licenses): Nonresident citizen, \$5.25 (on and after January 1, 1931, \$10.25). Nonresident, residing in a State affording similar privileges to residents of Massachusetts, who owns real estate assessed at not less than \$500, or who is a member of a hunting or fishing club or association incorporated prior to 1907, or who is a guest on written invitation of an incorporated club or association for hunting foxes, fee, \$2.25 (on and after January 1, 1931, \$3.25).

Resident citizen, \$2.25 (on and after January 1, 1931, \$2.75); not required of persons over 70. Alien, \$15.25 (applicant must have resided in State 10 days and own real estate therein to the assessed value of \$500). Duplicate of lost or destroyed license, fee, 50 cents. Issued by city and town clerks. Licenses must be carried on person, and exhibited on demand of officers, landowners, and agents.

Sporting licenses not issued to minors under 15, and those under 18 must apply in writing and furnish written consent of parent or guardian. A license (fee, 75 cents; \$1.25 after January 1, 1931) to trap quadrupeds may be issued to a minor between ages of 15 and 18 upon written consent of parent or guardian.

Licensee required to report within 30 days after January 1, number of each species of birds and animals taken by him.

Resident may hunt during open season without a license on land owned or leased on which he is actually domiciled and which is used exclusively for agricultural purposes, and not for club, shooting, or fishing purposes, and may fish in inland waters bordering such lands. License to fish not required of minors under 15.

Bag limits and possession: One deer a season; 2 hares and 5 rabbits a day or in possession; 5 gray squirrels a day, 15 a season; 4 quail a day, 20 a season; 2 pheasants a day, 6 a season; 3 ruffed grouse a day, 15 a season; 4 woodcock a day, 20 a season; 15 ducks, 4 geese, 8 brant, 20 Wilson's snipe, 25 coots, 25 sora, and 25 in all of other rails and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules a day. Resident may possess for own use during close season game legally taken or acquired by him, but migratory game birds may only be possessed 10 days after close of season.

Not more than 30 ducks and 8 geese may be possessed at any one time.

³⁷ See footnote on p. 19, col. 2.

³⁸ Massachusetts: Governor may suspend open seasons during extreme drought.

⁴⁰ Commission may open season on pheasants.

⁴¹ License required to fish in inland waters.

Interstate transportation: A nonresident under his license may take out fish and game lawfully taken if carried open to view. A resident may export all game lawfully killed, but not more than two days' bag limit of migratory birds may be exported in any one calendar week.

Game taken outside of State and legally exported may be possessed for personal use.

Sale: Sale of all game prohibited; provided, deer, moose, caribou, and elk lawfully killed and coming from without State, under warden's tag, may be sold under license at any time. Hares or rabbits lawfully obtained and coming from a State where their sale is not prohibited may be sold under license.

Miscellaneous: Deer may be taken with a shotgun and bow and arrow only. Unlawful to hunt or kill game with rifle or revolver during open season for deer, or to have dog in woods.

Unlawful to import or liberate any live game birds or animals except under permit.

Hunting prohibited on State highways and within 50 yards thereof.

MICHIGAN

Open seasons:⁴²

Dates inclusive

Deer (male, with horns not less than 3 inches above skull), in Upper Peninsula, and in Alcona, Alpena, Benzie, Cheboygan, Crawford, Iosco, Kalkaska, Leelanau, Montmorency, Ogemaw, Oscoda, Otsego, Presque Isle, and Roscommon Counties only	Nov. 15-Nov. 30.
In rest of State	No open season.
Bear	Nov. 15-Nov. 30.
Rabbit, varying hare (snowshoe or jack rabbit):	
Upper Peninsula	Oct. 1-Jan. 31.
Lower Peninsula	Oct. 15-Jan. 1.
Fox squirrel, male Chinese or ring-necked pheasant (see exception)	Oct. 25-Oct. 31.
Exception: Pheasant in Upper Peninsula	No open season.
Ruffed grouse (partridge), prairie chicken (see exception)	Oct. 15-Oct. 20.
Exception: In Upper Peninsula	No open season.
Woodcock	Oct. 15-Oct. 31.
Duck, goose, brant, coot, Wilson's snipe or jacksnipe	Sept. 16-Dec. 31.
Rails and gallinules, other than coot	Oct. 1-Nov. 30.

No open season: Elk, moose, caribou, doves, quail, squirrels (black or gray), Canada or spruce grouse, hen pheasants, Hungarian partridges, wild turkeys, swans, wood duck, elder ducks, auks, bitterns, sandhill and whooping cranes, gannets, grebes, gulls, herons, jaegers, loons, murrelets, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident: Deer and bear, \$50; small game, \$10; fish, general, \$5; angling, \$3. Fishing license not required of person under 18. Resident: Deer and bear, \$2.50; small game, \$1.25; trout, \$1; camping party, \$3 (1 buck deer by camping party of four or more). Issued by county clerks, director, or deputy. Hunting license issued to persons under 17 and over 12 on application of parent or guardian, who must accompany such minors when hunting. License button must be displayed on outer garment. Residents and minor children may hunt without a license, during open season, small game on own inclosed land on which they reside. Unlawful to hunt on posted farm lands without consent of owner or person in possession.

Bag limits and possession: One deer, 1 bear, a season; 5 fox squirrels a day, 10 in possession, 15 a season; 5 rabbits a day, 5 in possession in Upper Peninsula, 10 in possession in Lower Peninsula, 50 a season; 5 each of ruffed grouse or prairie chickens a day, 10 each a season or in possession; 2 Chinese or ring-necked pheasants a day, 4 a season or in possession; 15 ducks a day, 30 in possession, 100 a season; 4 geese, 5 brant a day, but not more than 5 of both combined a day or in possession; 10 combined a season; 4 woodcock a day, 8 in possession, 16 a season; 10 Wilson's snipe a day, 20 in possession, 50 a season; 10 coots a day, 20 in possession, 50 a season; 10 rails and gallinules combined a day, 20 in possession, 50 a season. Deer and bear lawfully killed may be possessed during first 30 days of close season, and game birds and other game animals during first 10 days thereof. Camping party of not less than four licensed hunters may, under permit (fee, \$3), kill 1 deer for camp purposes.

Interstate transportation: Export prohibited of all protected game. *Exceptions:* (1) Deer and bear may be transported outside of State to reach a point within State. (2) Nonresident licensee may take out as hand baggage, open to view, possession limit of game birds, rabbits, and squirrels, and may ship 1 deer and 1 bear lawfully killed by himself when deer license tag and seal are attached. (3) Heads and skins of deer and bear, green or mounted, lawfully taken, may be exported under permit.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale prohibited of all protected game, except rabbits lawfully killed and imported within 15 days, provided heads and skins of deer and bear green or mounted, lawfully taken, may be sold or transported under permit.

MINNESOTA

Open seasons:⁴³

Dates inclusive

Deer (season closed in odd, open in even years)	Nov. 15-Nov. 25.
Bear, even years	Nov. 15-Nov. 25.
Odd years	Apr. 15-May 15.
Varying hare or snowshoe rabbit	No close season.
Squirrel (gray or fox)	Oct. 15-Jan. 1. ⁴⁴
Quail	Oct. 15-Nov. 20.
Male ring-necked pheasant (season closed in odd, open in even years)	Oct. 15-Nov. 1.
Prairie chicken or pinnated grouse, white-breasted or sharp-tailed grouse (season closed in even, open in odd years)	Sept. 16, 1931.
Mourning dove	Sept. 16-Oct. 1.
Duck (except wood duck), goose, brant, coot, Wilson's snipe or jacksnipe	Sept. 16-Dec. 31.
Rail and gallinule, other than coot	Sept. 16-Nov. 30.

No open season: Elk, moose, caribou, black squirrels, ruffed grouse, Canada spruce grouse, prairie chicken, ring-necked pheasant hens, Hungarian gray partridges, wild turkeys, upland plover, woodcock, black-bellied and golden plovers, swans, wood duck, elder ducks, auks, bitterns, little brown, sand-hill, and whooping cranes, grebes, gulls, herons, jaegers, loons, terns, and all shore birds (except Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident or alien: Big game, \$50.25 (includes 25 cents for metal-locking deer seal); small game, \$25. Fishing license, \$3 (not required of persons under 16 years of age if parent or guardian is licensed). Issued by commissioner, county auditors, and agents. Resident: Big-game animals, \$2.25 (in-

⁴² *Michigan:* Director upon approval of conservation commission may shorten or close the season and otherwise restrict the taking of any species of game for a period of not to exceed five years in any county. Such orders may be modified or rescinded when conditions warrant.

⁴³ *Minnesota:* Seasons subject to change by regulations. All hunting prohibited within 3 miles of corporate limits of Duluth, Minneapolis, and St. Paul.

⁴⁴ Squirrels protected within corporate limits of any city or village, or within a quarter of a mile thereof.

cludes 25 cents for metal-looking deer seal); small game, \$1; fish, 50 cents (family license to fish, \$1—includes identification card for each member of family 18 years of age or over); fishing license not required of resident under 18; fish house, \$1—Issued by county auditor. Hunting license not required of persons under 18 and owners, lessees, or members of their immediate families may hunt birds or animals (except deer or moose) during open season on own or leased land occupied by them as permanent residence without license.

Any person taking protected wild animals or birds, with or without license, must report to State game commissioner, on or before Jan. 31, number of each kind of game killed during preceding calendar year. Unlawful to enter growing grainfields for purpose of hunting without permission of owner.

Bag limits and possession: One deer a season; 7 squirrels a day, 14 in possession; 4 geese, 12 ducks, and 15 in all of coots, gallinules, Wilson's snipe or jacksnipe, and rails a day, 36 in all in possession, of which not more than 5 may be geese and 30 may be ducks; 120 ducks a season; 10 quail a day, 15 in possession, 30 a season; mourning doves, 9 a day, 30 in possession, 30 a season; 3 ring-necked pheasants a day, 12 in possession, 15 a season, but not more than 15 game birds in all in one day. Possession permitted during first 5 days of close season. Under permit or tags deer may be possessed to February 28, migratory birds for 10 days after close of season, but no game birds may be possessed after January 10.

Interstate transportation: Export of all protected game prohibited, except that nonresident licensee may ship home in open season under his license coupons 1 deer and 25 birds lawfully taken by himself, but not more than the possession limit of any one species a season; not more than 5 geese may be exported by one licensee. Deer hides for tanning and heads for mounting may be exported when tagged with license coupons (deer season closed in odd years.)

Game taken outside of State and legally exported may be possessed at any time under a retaining tag, obtained from State game and fish commissioner, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Sale: Sale of all protected game prohibited; provided, hides of deer legally killed may be sold.

Miscellaneous: Unlawful to carry gun in motor vehicle unless unloaded in both barrel and magazine and taken apart or contained in a case. Unlawful to keep game in cold storage.

MISSISSIPPI ⁴⁵

Open seasons:	Dates inclusive
Deer (male).....	Nov. 20-Dec. 31.
Squirrel.....	Oct. 1-Dec. 31.
Hare, rabbit.....	No close season.
Quail or partridge (bobwhite).....	Nov. 20-Jan. 31.
Wild-turkey gobblers.....	Apr. 1-Apr. 15.
Dove.....	Sept. 1-Sept. 30.
Woodcock.....	Nov. 20-Jan. 31.
Waterfowl, Wilson's snipe or jacksnipe, coot, poule d'eau.....	Nov. 1-Jan. 31.
Rail and gallinule, other than coot.....	Sept. 1-Nov. 30.

No open season: Does and spotted fawns; bear, turkey hens, ruffed grouse, pheasants, western quail, swans, wood duck, bitterns, sand-hill cranes, grebes, gulls, herons, loons, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident: Game, State, \$15; county, \$10; fish, \$2 (county). Resident: Game, State, \$3; county, \$1 to \$3 in discretion of board of supervisors. Issued by sheriff. License not required for hunting rabbits nor of persons under 16 or over 70. Landowners

may hunt during open season on own lands without license. Written permission of owner or agent required to hunt, trap, or fish on posted lands of another.

Bag limits and possession: One deer a day, 3 a season; 15 squirrels a day; 2 turkey gobblers a season; 15 quail a day; 15 ducks, 4 geese, 8 brant, 20 Wilson's snipe, 4 woodcock, 25 doves, 25 coots, 25 sora, but not more than 25 in all of rails (other than sora), coots, and gallinules, and not more than 15 of any one species of rails (other than sora) and gallinules a day. Nonresident limited to not more than 25 migratory game birds of all kinds in one day. Possession of migratory birds permitted during first 10 days of close season, but not more than 30 ducks and 8 geese may be possessed at any one time.

Interstate transportation: Export of all protected game prohibited, except that a nonresident licensee may take out in personal possession one day's limit of game birds he has lawfully killed.

Game taken outside of State and legally exported may be possessed only during open season in State, but migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Sale: Sale of all protected game (except rabbits) prohibited.

MISSOURI

Open seasons:	Dates inclusive
Wild turkey.....	Dec. 1-Dec. 31.
Squirrel.....	June 1-Nov. 30.
Quail (bobwhite partridge).....	Nov. 10-Dec. 31.
Dove.....	Sept. 1-Dec. 15.
Duck, goose, brant, Wilson's snipe, coot.....	Sept. 24-Jan. 7.
Woodcock.....	Nov. 10-Dec. 10.
Rail and gallinule, other than coot.....	Sept. 15-Nov. 30.

No open season: Deer (1933), ruffed grouse (pheasants), prairie chickens (pinnated grouse), imported pheasants, other introduced game birds, swans, wood duck, bitterns, little brown, sand hill, and whooping cranes, grebes, gulls, herons, jaegers, loons, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident or alien: Game and fish, \$10; fish, \$3 (season); 15-day license, \$1. Issued by commissioner or county clerk. Resident: Game and fish: State, \$2.50; county, \$1, good in county of residence or adjoining county; fish (State), \$1. Issued by county clerk or license collector. Fishing license not required in county of residence nor of women or minors who are citizens. Owners and tenants of agricultural lands and members of family under 21 residing thereon may hunt without license during open season on own or leased land when used for agricultural purposes only, but may not transport or ship game or fur animals therefrom without a license. Hunting on land of another prohibited without his consent.

Bag limits and possession: One turkey a season; 10 squirrels, 10 quail, 10 doves, 15 ducks, 4 geese, 8 brant, 4 woodcock, 15 Wilson's snipe a day; 15 rails, 15 coots, 15 gallinules, but not more than 25 in all a day or in possession; or 1 turkey, 15 quail, 15 doves, 8 geese, 25 of any other species of birds in possession. Possession of migratory game birds permitted during first 10 days of close season, other game during first 5 days thereof.

State hunting license required to possess game. **Interstate transportation:** Export of all protected game prohibited, except that not more than two days' limit of game may be exported under resident or nonresident license if carried openly as baggage or express or in owner's possession and accompanied by him.

Game taken outside of State and legally exported may be possessed in like numbers and manner as game taken in State, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Sale: Sale of all protected game prohibited.

Miscellaneous: Unlawful to keep game in cold-storage establishments.

⁴⁵ Mississippi: Board of supervisors of any county may by regulation shorten or close seasons, reduce bag limits, or extend other protection to game within the provisions of the law.

MONTANA

Open seasons:⁴⁶

Dates inclusive

Deer (male with horns 4 inches above the skull) (see exceptions)..... Oct. 15-Nov. 15.

Exceptions: Deer, either sex, in Flathead, Glacier, Lake, Lincoln, Madison, Mineral, and Sanders Counties and in part of Ravalli County... Oct. 15-Nov. 15.

Deer, either sex, in part of Ravalli County..... Sept. 20-Oct. 20.

In Blaine, Carbon, Carter, Custer, Dawson, Gallatin, Garfield, Musselshell, McCone, Petroleum, Phillips, Powder River, Prairie, Richland, Roosevelt, Rosebud, Treasure, Valley, Yellowstone, and parts of Big Horn, Fergus, Glacier, and Pondera Counties..... No open season.

Elk, in Flathead, Glacier, Madison, Pondera, and parts of Gallatin, Lewis and Clark, Missoula, and Powell Counties..... Oct. 15-Nov. 15.

In Granite County and in part of Powell County..... Nov. 10-Nov. 12.

In Jefferson County (bull only)..... Nov. 12-Nov. 14.

In part of Lewis and Clark County..... Nov. 1-Nov. 15.

In part of Lewis and Clark and Teton Counties..... Oct. 15-Dec. 1.

In Park County..... Oct. 15-Dec. 20.⁴⁷

In part of Ravalli County..... Sept. 20-Oct. 20.⁴⁷

Bear (unlawful to trap)..... No close season.

Pheasant, partridge, prairie chicken, fool hen, sage hen, grouse..... Sept. 16-Sept. 25.

Duck, goose, brant, Wilson's snipe or jacksnipe, coot..... Sept. 16-Dec. 31.

Rail and gallinule, other than coot..... Sept. 16-Nov. 30.

No open season: Mountain sheep, mountain goats (except as opened locally by commission); elk (except as above), does and fawns, moose, caribou, antelope, bison or buffalo; quail, introduced pheasants, Hungarian partridges, ptarmigan, wild turkeys,⁴⁸ doves, swans, wood duck, bitterns, little brown, sand-hill, and whooping cranes, grebes, gulls, herons, loons, band-tailed pigeons, terns, and all shore birds (except Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident citizen: General, \$30; game birds and fish, \$10; fish, \$3.50. Alien: General, \$50; fish, \$10. Resident citizen,⁴⁹ \$2. Guide (resident citizen), \$10. Shipping (export), 50 cents. Taxidermist, \$15. Issued by warden or deputy.

No license required of minors under 15. Alien not holding hunting license required to obtain from warden \$25 license to possess firearms.

Bag limits and possession: One buck (1 deer of any age or either sex in Flathead, Glacier, Lake, Lincoln, Madison, Mineral, Ravalli, and Sanders Counties), 1 elk a season; 5 in all of grouse, partridges, prairie chickens, fool hens, pheasants, and sage hens, a day or in possession; 15 ducks, 4 geese, 8 brant, 20 Wilson's snipe, 25 coots, 25 sora, 25 in all of other rails and gallinules, but not

more than 15 of any one species of rails (other than sora) and gallinules a day. Migratory game birds legally taken may be possessed during open season and first 10 days of close season, but not more than 30 ducks and 8 geese may be possessed at any one time.

Interstate transportation: Export of all protected game prohibited; provided, game lawfully killed may be exported by a resident under shipping permit (fee, 50 cents) from State warden; a nonresident may export under his license game he has lawfully taken; total shipments under permits or one license may not exceed season's bag limit and not more than two days' limit of migratory birds may be exported in any one calendar week; packages must be labeled to show contents.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of bears and all protected game prohibited; provided, merchant or hotel or restaurant keeper may sell game, except migratory birds, killed outside the State. Under permit, mounted specimens or hides or heads of game animals or birds lawfully taken may be sold.

NEBRASKA

Open seasons:

Dates inclusive

Squirrel..... Oct. 1-Dec. 31.

Rabbit..... No close season.

Dove..... Sept. 1-Sept. 15.

Duck, goose, brant, coot..... Sept. 16-Dec. 31.

Wilson's snipe or jacksnipe..... Sept. 16-Nov. 1.

Rails and gallinules, other than coot..... Sept. 16-Nov. 30.

No open season: Buffalo, deer, elk, antelope, mountain goats, mountain sheep, quail, partridges, sage hens, introduced pheasants⁴⁰ or partridges, prairie chickens, grouse (1931); ptarmigan, introduced game birds, wild turkeys, woodcock, swans, wood duck, bitterns, little brown, sandhill, and whooping cranes, grebes, gulls, herons, jaegers, loons, terns, and all shore birds (except Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident: Game, \$10.10; fish, \$2.10. Alien: Fish, \$5.10. Resident, \$1.10. Issued by game, forestation, and parks commission and authorized vendors. Licenses required of all persons over 15, but not issued to person under 16 without consent of parent or guardian. Consent of owner required to hunt on private premises. Alien not permitted to hunt, or to own or possess firearms.

Bag limits and possession: Ten squirrels a day, or in possession; 5 pheasants a day, or in possession; 20 ducks and coots a day, 40 in possession, but not more than 15 ducks a day or 30 in possession; 5 geese and brant combined a day or in possession, but not more than 4 geese a day; 15 doves a day or in possession; 15 Wilson's snipe a day or in possession; 15 rails and 15 gallinules a day or in possession, but not more than 25 in all of rails and gallinules a day; 40 in all of game birds in possession, but not more than 30 ducks and 5 geese may be possessed at any one time. Possession permitted during first 10 days of close season.

Interstate transportation: Game may be transported by express or baggage during the open season when tagged as required by commission, and shipper's statement that the game is not for sale or profit, and was not taken contrary to law, is furnished commission and a copy attached to shipment; package must be labeled with commissioner's license number and kind of game, consigned to shipper, and accompanied by him; shipment must not contain more than 40 game birds or the possession bag limit on any species. Not more than two days' limit of migratory birds may be exported in any one calendar week.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of all protected game prohibited.

⁴⁶ *Montana:* Commission may close season in any district on any species of game threatened with undue depletion from any cause, or reopen such districts, may advance the date of open season on sage grouse in any county, and may specify open seasons and bag limits, locally, on upland game birds on which season is closed.

⁴⁷ Commission may declare open seasons on and prescribe regulations governing hunting of elk in any portion of closed area, and on five days' notice close season on elk in Park and Teton Counties, and in part of Lewis and Clark County, and may shorten the season in Ravalli County.

⁴⁸ Resident licenses issued to officers of the Forest Service and of the Bureau of Biological Survey, members of United States Department of Agriculture, and to officers and members of the United States Army, Navy, or Marine Corps.

⁴⁹ *Nebraska:* Game, forestation, and parks commission, upon written request from any county board, may open season on pheasants in such county for 15 days or less between Sept. 16 and Dec. 31. Owner or occupant of farmlands may, under permit, kill pheasants damaging or destroying crops.

NEVADA

Open seasons: ⁵⁰	Dates inclusive
Deer (male with branched horns).....	Oct. 1-Oct. 31.
Bear, squirrel.....	No close season.
Cottontail rabbit, mountain hare.....	Nov. 1-Dec. 31.
Sage hen ⁵¹	July 25-Aug. 3.
Quail, pheasant.....	Nov. 1-Nov. 5.
Dove.....	Sept. 1-Dec. 15.
Duck, goose, brant, coot, Wilson's snipe or jacksnipe.....	Sept. 16-Dec. 31.
Rail and gallinule, other than coot.....	Sept. 1-Nov. 30.

No open season: Mountain sheep, mountain goats, antelope except as permitted by commission; elk, does, fawns, and spike bucks; swans, wood duck, bitterns, little brown and sand-hill cranes, grebes, gulls, herons, loons, murres, band-tailed pigeons, terns, and all shore birds (except Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident citizen:⁵² Game, \$10; fish, \$3. Alien, fish, \$7.50. Resident citizen: Game, \$2.50; fish, \$1.50. Deer tags, fee \$1, required of holders of licenses to hunt deer. Issued by county clerks and wardens. Aliens prohibited from hunting. No license required of boys and girls under 14.

Bag limits and possession: One deer a season; 5 cottontail rabbits, 2 mountain hares, 10 valley quail, 5 mountain quail, 3 partridges, 3 grouse, 3 pheasants, 5 prairie chickens, 10 sage hens, 15 ducks, 4 geese, 5 brant, 10 snipe, and 25 doves a day or in possession; 25 coots, 25 sora, and 25 in all of other rails and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules a day. One day's limit of game lawfully taken may be possessed during first 60 days of close season, under permit, except migratory game birds may not be possessed for more than 10 days after close of season. Deer lawfully taken in another State and exported may be personally brought into State by the taker during close season.

Interstate transportation: Export of all protected game prohibited, except holder of a deer-license tag may export a deer legally killed there-under upon the tag being countersigned by a regular deputy, commissioner, or officer authorized to administer oaths. Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of deer meat and of all other protected game is prohibited.

NEW HAMPSHIRE

Open seasons: ⁵³	Dates inclusive
Deer, in Coos County.....	Oct. 15-Nov. 30.
In Carroll County.....	Nov. 15-Dec. 15.
In Cheshire County.....	Dec. 1-Dec. 15.
In Grafton County.....	Nov. 1-Dec. 15.
In rest of State.....	Oct. 1-Dec. 31.
Hare, rabbit.....	Oct. 1-Feb. 28.
Partridge, ruffed grouse (see exception).....	Oct. 1-Nov. 30.
Exception: In Coos and Cheshire Counties.....	Oct. 1, 1931.
Pheasant (male) in Hillsborough, Merrimack, Rockingham, and Strafford Counties only.....	Nov. 1-Nov. 6.

⁵⁰ Nevada: Fish and game commission fixes open seasons on deer with branched horns and upland game birds, and county commissioners may shorten or close season entirely on deer, upland game, or migratory game birds.

⁵¹ Sage hens may be hunted only on Wednesday, Saturday, Sunday, and legal holidays during open season.

⁵² Citizen of any State must pay same fee for hunting or fishing license as charged nonresidents by his State of residence.

⁵³ New Hampshire: Governor and council may suspend open season in time of excessive drought or emergency. Owner of farm lands may take at any time gray squirrels doing actual damage to his crops.

Open seasons—Continued.	Dates inclusive
Woodcock.....	Oct. 1-Oct. 31.
Duck, goose, brant, Wilson's snipe or jacksnipe, coot.....	Sept. 16-Dec. 31.
Rail, other than coot and gallinule.....	Sept. 1-Nov. 30.
Gallinule.....	Sept. 16-Nov. 30.

No open season: Elk, moose, caribou, doves, quail, pheasants (except as above), European partridges; gray squirrels (1935)⁵⁴; swans, wood duck, eider ducks, auks, bitterns, sand-hill cranes; gannets, grebes, guillemots, gulls, herons, jaegers, loons, murres, petrels, puffins, shearwaters, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident: Game and fish, \$15.15; fish, \$3.15. Resident: Game and fish, \$2. Resident soldiers and sailors more than 70 years of age may obtain license free on application to fish and game commissioner. Fishing licenses not required of children under 16 or of blind persons. Issued by commissioner or his agent in each town, who with few exceptions is the town clerk. Children under 16 may hunt without license when accompanied by licensed parent or guardian. Resident owner of farm lands and his minor children may hunt during open season, on own land without license. Guide: Nonresident, \$20; resident, \$1. Issued by commissioner.

Bag limits and possession: One deer a season; 5 hares a day; 5 ruffed grouse a day, 25 a season; 2 pheasants a day, 5 a season; 4 woodcock a day, 25 a season; 15 ducks, 4 geese, 8 brant, 20 Wilson's snipe, 25 coots, 25 sora, and 25 in all of other rails and gallinules but not more than 15 of any one species of rails (other than sora) and gallinules a day. Not more than 30 ducks and 8 geese may be possessed at any one time. Deer may be possessed for a reasonable time after close of open season.

Interstate transportation: Export of all protected game prohibited, provided head, hide, feet, or fur of game quadrupeds, and plumage or skins of game birds (except migratory birds) legally taken and possessed may be transported in State without being marked, but under Federal laws all interstate shipments must be marked as to contents. Nonresident may take or ship out of State, under his hunting license, one day's limit of game birds, and under license coupon, one deer. Shipments by common carrier must have attached tag showing number and kind of game, names of consignor and consignee, and point of shipment and destination, and shipment or transportation of game must be indorsed on back of shipper's license.

Deer must be tagged with license coupon before being moved.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of all migratory birds prohibited. Sale for food purposes prohibited of the dead bodies of birds belonging to a family any species or subspecies of which is native to and protected by State; provided deer, hares, and rabbits may be sold during open season for consumption as food only within State.

NEW JERSEY

Open seasons:	Dates inclusive
Deer ⁵⁴ (male, with horns not less than 3 inches long).....	Dec. 17-Dec. 21.
Raccoon.....	Oct. 1-Dec. 15.

⁵⁴ New Jersey: Wild deer may be taken only with shotgun not smaller than 12 gauge, which may not be loaded with a bullet or other missile larger than buckshot. Killing of a deer must be reported to commission or county warden within 48 hours. Landowner or his authorized agent may kill deer on his own cultivated land at any time under permit of commission; carcass of deer so killed is the property of the commission, and killing must be reported within 48 hours.

Open seasons—Continued.

Dates inclusive

Rabbit, ⁵⁵ gray, ⁵⁶ fox, and black squirrels, quail, ruffed grouse (partridge), prairie chicken, English or ring-necked pheasant cocks (see exceptions).....	Nov. 10-Dec. 15.
<i>Exceptions:</i> Quail in Bergen, Essex, Hudson, Hunterdon, Morris, Passaic, Somerset, Sussex, Union, and Warren Counties.....	Mar. 15, 1933.
Ruffed grouse in Essex, Hunterdon, Mercer, Middlesex, Monmouth, Somerset, and Union Counties.....	Mar. 9, 1932.
Duck (except wood duck and eider ducks), goose, brant, Wilson's snipe or jacksnipe, coot.....	Oct. 16-Jan. 31. ⁵⁶
Woodcock.....	Oct. 15-Nov. 14. ⁵⁶
Rail and gallinule.....	Sept. 1-Nov. 30. ⁵⁶

No open season: Does and fawns, wild turkeys, English or ring-necked pheasant hens, Hungarian partridges, reedbirds, doves, swans, wood duck, eider ducks, auks, bitterns little brown, sandhill, and whooping cranes, fulmars, gannets, grebes, guillemots, gulls, herons, jaegers, loons, murrets, petrels, puffins, shearwaters, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident and alien: Game and fish, \$10.50; fish (in fresh waters), \$5.50. Resident male citizen above age of 14: Game and fish, \$1.65; when applied for by parent or legal guardian, in discretion of commission, license may be granted to citizen between ages 10 and 14 to hunt when accompanied by adult holder of a general license: Fee, \$1; issued only by commission. Special license to hunt woodcock from Oct. 15 to Nov. 9, fee \$2, required in addition to regular hunting license; issued by commission. All other licenses, except as indicated, issued by county, city, or town clerk, salaried warden, or registrar of licenses. Licensee required to wear in a conspicuous place on his outer clothing a license button. Occupant of farm and immediate members of his family residing thereon with him may hunt or fish on such farm during open season without license. Hunting on occupied posted lands of another prohibited.

Alien prohibited from hunting or owning shotgun or rifle unless he is owner of real property in New Jersey to the value of \$2,000 above all incumbrances, in which case he may obtain nonresident and alien license.

Bag limits and possession: One deer a year; 2 English or ring-necked pheasant cocks a day, 30 a season; 6 rabbits, 6 gray squirrels, 10 quail, 3 ruffed grouse, 4 woodcock, 8 brant, 20 snipe, 25 sora, 25 coots, and 25 in all of other rails, coots, and gallinules but not more than 15 of any one species of rails (other than sora, marsh hens, and coot) and gallinules a day or in possession; 15 ducks, 4 geese a day, but not more than 25 ducks and 8 geese may be possessed at any one time. Deer carcasses from another State or a State game preserve may be possessed at any time if properly tagged to show where killed; possession of other game permitted during first 10 days of close season.

Interstate transportation: Export of all protected game (except deer) prohibited, except that a nonresident licensee in one day may carry from State the daily bag limit of game, if open to view, but not more than two days' limit of game may be exported in one calendar week.

⁵⁵ Rabbits and gray squirrels may be killed or trapped on own premises at any time by farmers or fruitgrowers under permit from commission.

⁵⁶ Migratory game birds may not be killed at any time on Shark River, or the shores thereof, in Monmouth County.

Game taken outside of State and legally exported may be possessed at any time, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Sale: Sale of deer, squirrels, and all game birds prohibited; rabbits may be sold during open season and 10 days thereafter; cottontail rabbits, Belgian hares, and jack rabbits legally killed and coming from another State may be sold at any time.

Miscellaneous: Unlawful to use shotgun or rifle holding more than two cartridges or that may be fired more than twice without reloading.

NEW MEXICO

Open seasons:⁵⁷

Dates inclusive

Deer (with horns at least 6 inches in length), wild turkey, grouse, Abert's and Arizona gray squirrels.....	Nov. 10-Nov. 20.
Bear.....	Oct. 10-Oct. 31.
Quail (except bobwhite).....	Nov. 1-Dec. 31.
Prairie chicken.....	Sept. 1-Sept. 5.
Turtle dove and white-winged dove.....	Sept. 1-Dec. 15.
Duck, goose, brant, Wilson's snipe, coot.....	Oct. 16-Jan. 31.
Rail and gallinule, other than coot.....	Sept. 1-Nov. 30.

No open season: Does, Sonoran deer, elk, mountain sheep, mountain goats, antelope, buffalo, bobwhite quail, pheasants, ptarmigan, sage hens, swans, wood duck, bitterns, little brown, sandhill, and whooping cranes, grebes, gulls, herons, loons, band-tailed pigeons, terns, and all shore birds (except Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident: Big game, bird, and fish, \$35.25; big game and bird, \$30.25; big game, \$25.25; bird, \$10.25; fish: General \$3; limited, \$1.25. Resident: Big game, bird, and fish, \$5; big game and bird, \$4.50; bird and fish, \$4.50; big game, \$3; bird, \$2.50; fish: General, \$2; limited, \$1.25; guide, \$5.25; duplicate, \$1. Issued by county clerks and deputies designated by State warden. Fishing license not required of children under 14. Alien resident of New Mexico or an adjoining State not permitted to hunt or to own or possess shotgun or rifle in State.

Bag limits and possession: One deer, 1 bear, 5 squirrels, 2 wild turkeys, 10 prairie chickens, 5 grouse, a season or in possession; 15 quail, 5 prairie chickens a day or in possession; 20 doves, 15 ducks, 4 geese, 8 brant, 20 Wilson's snipe, 25 coots, 25 sora, and 25 in all of other rails and gallinules but not more than 15 of any one species of rails (other than sora) and gallinules a day or in possession, but not more than 15 ducks and 4 geese may be possessed at any one time. Possession permitted during open season and first 10 days of close season. Under permit, game, except migratory birds, may be held in storage for first 90 days of close season; migratory birds may be so held for a period of 10 days.

Interstate transportation: Licensee may carry out of State during open season game legally killed, but permits issued by State game warden and license collectors are required to ship game out by common carrier: Fee, \$1.25 for 1 deer, 1 bear, and 2 turkeys, and 50 cents for bag limit of other birds and fish.

Game taken outside of State and legally exported, when accompanied by permit or proof of lawful possession, may be possessed under permit obtained from State game and fish warden during open season and first 30 days of close season, but migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Sale: Sale of all protected game taken in State prohibited.

⁵⁷ *New Mexico:* Commission may close season in any locality on any species, and may prohibit all hunting, in periods of extreme forest-fire danger, at such times and places as may be necessary.

NEW YORK

Open seasons: ⁴⁸

Dates inclusive

Deer (with horns not less than 3 inches long):	
In Adirondack region ⁴⁹	Oct. 15-Nov. 15.
In Ulster, Sullivan, Rensselaer, Delaware, Columbia, Orange, and Dutchess ⁵⁰ Counties.....	Nov. 1-Nov. 15.
In Greene County.....	Nov. 1-Nov. 8.
In rest of State.....	No open season.
Bear ⁵¹	Oct. 15-Nov. 15.
Varying hare ⁵²	Oct. 15-Mar. 1.
Cottontail rabbit ⁵³ (see exception).....	Oct. 15-Jan. 31.
Exception: In Wayne, Ontario, Orleans, Livingston, Monroe, Niagara, Cayuga, Schuylcr, Tompkins, and Onondaga Counties.....	Oct. 15-Mar. 31.
Squirrel (black, gray) ^{54 55}	Oct. 15-Nov. 15.
Quail, in Dutchess, Greene, Orange, Putnam, Rensselaer, Sullivan, and Westchester Counties only.....	Nov. 15-Nov. 30.
Grouse or partridge (see exception).....	Oct. 1-Nov. 15.
Exception: In Greene, Delaware, Ulster, Rockland, Columbia, Putnam, Dutchess, Rensselaer, Sullivan, Orange, Schoharie, and Westchester Counties.....	Oct. 15-Nov. 30.
Pheasant, male only ⁵⁶ (4 days only) (except in Essex County, no open season).....	Oct. 23 and 30. Nov. 1 and 8.
Waterfowl, Wilson's snipe or jacksnipe, coot.....	Sept. 24-Jan. 7.
Woodcock.....	Oct. 1-Oct. 31.
Rail and gallinule, other than coot.....	Sept. 24-Nov. 30.

No open season: Elk, moose, caribou, antelope, fawns; fox squirrels; Hungarian or European gray-legged partridges, doves, quail (except as above), swans, wood duck, elder ducks, auks, bitterns, sand-hill and whooping cranes, fulmars, gannets, grebes, guillemots, gulls, herons, jaegers, loons, murrets, petrels, puffins, shearwaters, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting, trapping, and fishing licenses (combined): Nonresident: \$10.50; fish only, \$5.50. Resident, \$1.25. Special deer license: Nonresident or alien, \$10.50; resident, \$1.25. Issued by county, city, town, and village clerks where population exceeds 5,000; elsewhere by department and inspectors and protectors; license not issued to minor under 16. Indian resident or member of Six Nations residing on any reservation wholly or partly within State, \$1.25. Only

⁴⁸ *New York:* Commission by order may further restrict taking or possession of game. Open seasons on upland game have been restricted to the following periods or closed as indicated: *Squirrel* (black, gray), in Genesee, Niagara, Orleans, and Seneca Counties no open season. *Cottontail rabbit*, in Erie County, Oct. 15-Dec. 31; in Genesee County, Oct. 15-Dec. 31; in Niagara County, Oct. 15-Jan. 1; in Rockland County, Nov. 1-Dec. 31. *Varying hare*, in Fulton and Onondaga Counties, Oct. 15-Jan. 31; in Cattaraugus and Genesee Counties, no open season. *Pheasant*, in Essex County, no open season.

⁴⁹ The Adirondack region comprises the counties of Clinton, Essex, Franklin, Fulton, Hamilton, Herkimer, Jefferson, Lewis, Oneida, Oswego, Saratoga, St. Lawrence, Warren, and Washington.

⁵⁰ In Dutchess County deer may be taken only on own land by owner or lessee, or member of his immediate family, by use of shotgun loaded with missile not smaller than buckshot.

⁵¹ Bear unprotected in Clinton, Delaware, Essex, Franklin, Greene, and Ulster Counties, but bear taken in those counties between Nov. 21 and Oct. 15 may be possessed only under license and by marking and tagging as provided for animals taken during open season elsewhere in State.

⁵² In corporate limits of city or village squirrels may be taken only under permit of commission.

licensed Indians residing on a reservation may hunt thereon. Licensee required to wear button. Fishing license not required of women who are bona fide residents of State nor of minors under 16. Owners or lessees, and members of immediate families who are citizens actually occupying cultivated farm land may hunt thereon without license during open season. Guide (required in forest reserve counties), license fee, \$2; issued by conservation department. Alien not permitted to hunt except under special license from conservation department, or to own or possess shotgun or rifle.

Bag limits: One deer, 1 bear, 3 grouse or partridge a day, 15 a season; 3 male pheasants a season; 4 woodcock a day, 24 a season; 6 varying hares or rabbits, 5 squirrels, 15 ducks, 4 geese, 8 brant, 25 in all of ralls, coots, and gallinules, but not more than 15 of any one species, 20 Wilson's snipe or jacksnipe a day.

Local bag limits: Quail, 4 a day, 10 a season, in Dutchess, Greene, Orange, Putnam, Rensselaer, Sullivan, and Westchester Counties.

Possession: Deer, bear, squirrel, grouse, and pheasant during open season and 5 days thereafter; migratory game birds during open season and 10 days thereafter, but not more than 30 ducks and 8 geese may be possessed at any one time. Deer and bear properly tagged may be possessed under \$1 permit to Feb. 1.

Interstate transportation: Export of game and birds prohibited except that any person may export 1 deer, 1 bear, and one day's limit of other game in one day during open season by means other than parcel post. The taker may export in one day by common carrier, except parcel post, one day's limit when accompanied by permit, which shall show contents of package. Head, hide, and feet of animals and plumage or skin of game birds legally taken may be exported at any time.

Game taken outside of State and legally exported may be brought into State during open season therein and possessed the same as if taken in State. Migratory game birds may be possessed during open season where taken and first 10 days of close season. Importation permit, fee \$1, obtained from conservation department, required to import game during close season, and then game birds must be accompanied by taker, while quadrupeds bearing New York importation tags may be shipped by common carrier, but not by parcel post. Game other than migratory birds imported under importation permit may be possessed at any time by permit holder for private consumption.

Sale: Sale of all game, except varying hares and rabbits, prohibited; varying hares and rabbits legally taken in State may be sold during open season, and when brought from without the State may be sold at any time.

Head, hide, and feet of quadrupeds legally taken and possessed may be sold at any time.

Miscellaneous: Hunting prohibited on lands supplying any municipality with water or on public highways, except public highways within forest preserve counties.

NEW YORK—Long Island

Open seasons:	Dates inclusive
Squirrel (black, gray), quail, pheasant (male only).....	Nov. 1-Dec. 31.
Varying hare.....	Oct. 15-Mar. 1.
Cottontail rabbit.....	Nov. 1-Dec. 31.
Grouse.....	Nov. 1-Dec. 31.
Waterfowl, Wilson's snipe or jacksnipe, coot, mud hen.....	Oct. 16-Jan. 31.
Woodcock.....	Oct. 1-Oct. 31.
Rail and gallinule, other than coot.....	Sept. 24-Nov. 30.

No open season: Deer, fox squirrels, doves, swans, wood duck; elder ducks, auks, bitterns, sand-hill and whooping cranes, fulmars, gannets, grebes, guillemots, gulls, herons, jaegers, loons, murrets, petrels, puffins, shearwaters, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Bag limits and possession: Six quail a day, 40 a season; 4 male pheasants a day, 30 a season. For other bag limits see New York.

Hunting licenses, interstate transportation, sale, miscellaneous (see New York).

NORTH CAROLINA

Open seasons: ⁶³	Dates inclusive
Deer (male), bear ⁶⁴	Oct 1-Jan. 15.
Rabbit, ⁶⁴ quail, wild turkey.....	Nov. 20-Feb. 15.
Squirrel, east of and including Person, Orange, Chatham, Moore, Richmond, and Scotland Counties.....	Oct. 15-Jan. 15. Sept. 15-Jan. 1.
In rest of State.....	Nov. 20-Jan. 31.
Dove.....	Dec. 1-Dec. 31.
Woodcock.....	Nov. 1-Jan. 31. ⁶⁵
Duck, goose, brant, coot, Wil- son's snipe or jacksnipe.....	Sept. 1-Nov. 30.
Rail (except coot and gallinule).....	Nov. 1-Nov. 30.
Gallinule.....	

No open season: Buffalo, elk; does (1931); ruffed grouse, Mongolian, Chinese, or ring-necked pheasants (1931); swans, wood duck, reedbirds, auks, bitterns, gannets, grebes, gulls, herons, jaegers, loons, murrets, petrels, shearwaters, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident⁶⁶ or alien: Game, \$15.25;⁶⁶ game and fish, \$17.25; game and fur animals, \$35.25; fish, \$3.10. Nonresident owning land in State may obtain license to hunt thereon, fee, \$5.25. Resident (State licenses), game, \$3.25; game and fish, \$4.50; game and fur animals, \$5.25; fish, \$2.10. County licenses: Game, \$1.25; game and fur animals, \$3; fish, \$1.10. Hunting guide license, \$5. Issued by superior court clerks, wardens, and deputies. Person under 16 who is member of family resident of State may hunt under license of his parent or guardian; nonresident minor child of a resident may procure and use resident hunting license when actually visiting such resident parent. Resident landowner and dependent member of his family under 21 may hunt on own land during open season without license. Lessee of farm for cultivation may hunt thereon without license. License not required for fishing in Atlantic Ocean, the sounds, or other large bodies of water as designated by commission, nor of landowner or member of family under 21 for fishing in waters on his own land, nor of person under 16. Fishing licensee must wear license button. All licenses expire August 1.

Bag limits and possession: Two deer a day or in possession at one time, 4 a season; 2 wild turkeys a day or in possession at one time, 5 a season; 10 squirrels, 10 quail, 4 woodcock, 25 doves, 15 ducks, 4 geese, 8 brant, 20 Wilson's snipe or jacksnipe, and 25 in all of rails, coots, and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules a day.

The game allowed in possession at one time is restricted to one day's limit on deer and wild turkeys and two days' limit on other game animals and birds.

Rabbits and squirrels lawfully taken may be possessed during open season and first five days of close season. Other game animals and birds may be possessed during open season and first 10 days of close season.

Interstate transportation: Export of all protected game (except rabbits during open season) prohibited, except that a nonresident licensee, under permit from State warden may export not more than 2 male deer and 2 wild turkeys a

season and not more than two days' limit of other game animals and birds a calendar week in any manner except by parcel post, if outside of package in which such game is transported is clearly marked with names and addresses of consignor and consignee and an accurate statement of number and kind of game contained therein.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of all protected game prohibited except rabbits and squirrels during open season.

NORTH DAKOTA⁶⁷

Open seasons:	Dates inclusive
Prairie chicken (pinnated grouse), sharp-tailed (white-breasted) grouse, Wilson's snipe.....	Sept. 16-Oct. 16.
Ruffed grouse in Bottineau, Cavalier, Pembina, and Rolette Counties.....	Oct. 7-Oct. 16.
Woodcock.....	Oct. 1-Oct. 16.
Duck, goose, brant.....	Sept. 16-Dec. 1.

No open season: Deer, elk, moose, antelope, quail, ruffed grouse, except as above, sage hens, English and Chinese ring-necked pheasants, Hungarian partridges, doves, rail, coot, gallinule, swans, wood duck, bitterns, little brown, sandhill, and whooping cranes, grebes, gulls, herons, loons, shearwaters, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident: Game, \$25; fish, \$3. Resident: Game, \$1.50; fish, 50 cents; taxidermist, \$1. Issued by commissioners, deputy, or county auditor. Fishing license not required of resident under 16 and nonresident under 12. Aliens not permitted to hunt. Person or member of family permanently residing with him may hunt, trap, or fish without license during open season on own lands or lands cultivated by him. Resident license may be issued to settler. No person permitted to enter cultivated or posted lands without consent of owner.

Bag limits and possession: Pinnated grouse (prairie chicken), sharp-tailed grouse, ruffed grouse, 5 of each or all combined a day, but not more than 10 of each or all combined in possession. Four geese a day, 8 in possession. Ducks, jacksnipe, quail, 15 of each or all combined a day, but not more than 2 days' bag limit of each or all combined in possession. Woodcock, 4 a day, 8 in possession. Resident licensee may, under permit, retain in possession for more than 5 days after close of season not to exceed the possession limits stated above.

Interstate transportation: Export of all protected game prohibited, except that resident licensee may, under special permit, ship to any point within or without State other than his own home, 10 protected game birds a season, but not more than 8 wild geese, or 8 woodcock, may be shipped in any one calendar week. Nonresident licensee may carry with him from State under license tag 2 days' limit of game, if open to view and labeled with his name and address and number of his license. Not more than two days' limit of migratory birds may be exported in any one calendar week.

Game taken outside of State and legally exported may be possessed in like numbers and manner as game taken in State, except that migratory game birds may be possessed under permit from game and fish commission first 10 days of close season.

Sale: Sale of all protected game prohibited, except that hides, heads, and trophies of big game lawfully taken may be sold at any time.

Miscellaneous: The training or running of any dogs known as "bird dogs," including pointers,

⁶³ North Carolina: On petition of 25 or more reputable citizens and after public hearing, duly advertised, department of conservation and development may change, close, or reopen seasons within the dates specified for State or any county or district thereof or change the bag limits when special circumstances make such changes desirable and may designate days in each week on which migratory waterfowl may not be taken.

⁶⁴ Department of conservation and development may change seasons on bears and rabbits.

⁶⁵ Rest days prescribed for waterfowl by certain county laws. Special regulations affecting waterfowl in Currituck, Dare, and Hyde Counties may be obtained from clerks of counties named.

⁶⁶ Boards of county commissioners may prescribe additional license fees for nonresidents hunting in their respective counties.

⁶⁷ North Dakota: The governor, on recommendation of game and fish commission, may by order close or open seasons, fix bag limits, or prescribe manner in which game may be taken, but such orders may not extend the open seasons or other provisions of the Federal regulations on migratory birds.

setters, and droppers, or allowing them to run loose in fields or on land where game birds may be found is prohibited between April 1 and November 1.

Resident licensee may ship or carry with him to own home, 2 days' bag limit of game lawfully taken.

OHIO

Open seasons:	Dates inclusive
Hare, rabbit.....	Nov. 15-Jan. 1. ⁶⁸
Squirrel.....	Sept. 15-Oct. 1.
Cock pheasant (introduced), Hungarian partridge.....	Nov. 15-Nov. 25.
Duck, goose, brant, Wilson's snipe, coot.....	Sept. 16-Dec. 31.
Woodcock.....	Oct. 15-Nov. 14.
Rail, other than coot and galli- nule.....	Nov. 1-Nov. 30.
Gallinule.....	Sept. 16-Nov. 30.

No open season: Deer, quail, ruffed grouse, hen pheasants, doves, swans, wood duck, eider ducks, bitterns, sand-hill and whooping cranes, grebes, gulls, herons, jaegers, loons, murrets, petrels, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident citizen: Game, \$15.25; fish, \$2.25 (rod and reel). Resident citizen: Game, \$1.25; fish, \$1.10 (rod and reel). Issued by county and township clerks. Rod and reel license not required of persons under 18. Persons under 16 when hunting with a gun must be accompanied by adult. Owners, tenants, or their children may hunt or fish without license during open season on own or leased lands. Written permission required to hunt on land of another.

Bag limits and possession: Four squirrels and 5 rabbits a day or in possession; 2 cock pheasants a day, 4 in possession; and 6 Hungarian partridges, 15 Wilson's snipe, 4 woodcock, 4 geese, 15 ducks, 25 coots, 25 sora, and 25 in all of other rails and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules, and not more than 25 coots and gallinules a day. Waterfowl, coots, and gallinules may be possessed during first 10 days of close season, but not more than 30 ducks and 8 geese may be possessed at any one time. Woodcock and jacksnipe may be possessed only during open season.

Interstate transportation: Export prohibited of all protected game (except rabbit) taken in State; provided, a nonresident may take with him from State under his hunting license 25 game animals killed by himself. Packages containing game or fur-bearing animals or parts thereof must be marked to show contents, initial point of billing, and names and addresses of consignor and consignee.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale prohibited of all protected game (except hare or rabbit during open season).

OKLAHOMA

Open seasons:	Dates inclusive
Squirrel.....	May 15-Dec. 31.
Quail.....	Nov. 20-Jan. 1. ⁶⁹
Duck, goose, brant, Wilson's snipe or jacksnipe, coot.....	Oct. 16-Jan. 31.
Dove.....	Sept. 1-Dec. 15.
Woodcock.....	Nov. 15-Dec. 15.
Rail and gallinule, other than coot.....	Sept. 1-Nov. 30.

No open season: Deer (1931); antelope, wild turkeys, prairie chickens, imported pheasants, swans; wood duck bitterns, little brown, sand-hill, and whooping cranes, grebes, gulls, herons, loons, band-tailed pigeons, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

⁶⁸ Ohio: Landowners, tenants, and employees may take hares or rabbits, when doing substantial damage to crops, trees, or shrubbery, at any time except on Sunday.

⁶⁹ Oklahoma: Quail may not be hunted except on Monday, Wednesday, and Friday of each week during open season and on Thanksgiving Day and on Christmas and New Year's Days or the preceding Saturdays if these fall on Sundays.

Hunting and fishing licenses: Game: Nonresident, \$15. Nonresidents in States bordering on Red River may procure special license (fee, \$2.50) to hunt migratory waterfowl on Red River within borders of Oklahoma. Alien, \$25; resident citizen, \$1.25. Fish: Nonresident, \$5; nonresident tourist, 10 days, \$1.25; resident (to use rod and line for game fish), \$1.25. Issued by warden, deputy, or county clerk. A person may hunt without license during open season on own or leased premises actually occupied by him. Fishing license not required of any person under 16 nor of women. Application of persons under 14 for a hunting license must be approved in writing by parent or guardian. Women required to have hunting licenses. Unlawful to shoot on or across highway or railroad right of way. Unlawful to hunt on lands of another without owner's permission.

Bag limits and possession: Ten squirrels a day; 10 quail a day, 50 a season; 6 prairie chickens a day, 12 in possession; 10 ducks a day, 50 a season; 4 geese a day, 12 a season; 8 brant a day; 20 Wilson's snipe a day, 25 coots, 25 sora, and 25 in all of other rails and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules, 25 doves, and 4 woodcock a day. Not more than 30 ducks and 8 geese may be possessed at any one time. Possession of game permitted during first 10 days of close season, and trophies or specimens of game lawfully taken may be possessed at any time.

Interstate transportation: Export prohibited of all protected game, but nonresident licensee may carry to his home two days' bag limit of game birds if license permit is attached.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale prohibited of all protected game.

OREGON ⁷⁰

Open seasons:	Dates inclusive
<i>District No. 1,⁷¹ west of Cascades:</i>	
Deer (male, with forked horns).....	Sept. 15-Oct. 20.
Bear in Jackson and Jose- phine Counties.....	Nov. 1-Nov. 30.
In rest of district 1.....	No close season.
Silver-gray squirrel (see ex- ception).....	Sept. 15-Oct. 20.
<i>Exception:</i> In Benton, Clackamas, Douglas, Josephine, Lane, Linn, Marion, Multnomah, Polk, Washington, and Yamhill Counties.....	No close season.
Mountain or plumed and California or valley quail in Coos, Curry, Douglas, Jackson, Josephine, and Yamhill Counties only.....	Oct. 15-Oct. 31.
Blue or sooty grouse, ruffed grouse or native pheasant, Chinese pheasant (see ex- ception).....	Oct. 15-Oct. 31.
<i>Exception:</i> Chinese pheas- ant in Clatsop, Curry, Lincoln, and Tillamook Counties.....	No open season.
Duck, goose, brant, coot, Wilson's snipe or jacksnipe. Rail and gallinule, other than coot.....	Oct. 1-Jan. 15. Oct. 1-Nov. 30.
<i>District No. 2,⁷¹ east of Cascades:</i>	
Deer (male, with forked horns).....	Sept. 15-Oct. 20.
Bear in Klamath County.....	Nov. 1-Nov. 30.
In rest of district 2.....	No close season.

⁷⁰ Oregon: Commission may open or close season on any species of game birds in any county or district for such time as it may designate and governor may suspend season on account of fire hazard in forest area.

⁷¹ District No. 1, west of Cascades, includes Benton, Clackamas, Clatsop, Columbia, Coos, Curry, Douglas, Jackson, Josephine, Lane, Lincoln, Linn, Marion, Multnomah, Polk, Tillamook, Washington, and Yamhill Counties. District No. 2, east of Cascades, includes all other counties in State.

Open seasons—Continued.

District No. 2—Continued.

Dates inclusive

Mountain or plumed and California or valley quail in Crook, Deschutes, Gilliam, Klamath, Lake, Morrow, Sherman, Umatilla, and Wasco Counties only on October 1, and on Wednesdays and Sundays.	Oct. 1-Oct. 31.
Blue or sooty grouse, ruffed grouse or native pheasant.	Sept. 10-Oct. 20.
Hungarian partridge in Morrow, Sherman, Umatilla, and Wallowa Counties only on Wednesdays and Sundays.	Oct. 1-Oct. 31.
Chinese pheasant in Baker, Crook, Deschutes, Gilliam, Grant, Hood River, Klamath, Morrow, Umatilla, Union, Wallowa, and Wasco Counties only on October 1, and Wednesdays and Sundays and daily in Malheur County.	Oct. 1-Oct. 31.
Duck, goose, ⁷³ brant, coot, Wilson's snipe or jacksnipe.	Oct. 1-Jan. 15.
Rail and gallinule, other than coot.	Oct. 1-Nov. 30.

No open season: Doe and spotted fawns, moose, elk, antelope, mountain sheep, mountain goats; Franklin's grouse, fool hens, wild turkeys, quail, introduced pheasants (except as above), bobwhite quail, sage hens, prairie chickens; doves; band-tailed pigeons, swans, wood duck, auklets, auks, bitterns, little brown and sand-hill cranes, fulmars, grebes, guillemots, gulls, herons, jagers, loons, murrets, petrels, puffins, shearwaters, terns, and all shore birds (except Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresidents: Game, \$15, angling, \$3. Alien: Gun license, \$25 (in addition to hunting and angling license). Resident, game and fish, \$5; game, \$3; angling, \$3; hunting, \$1.50; angling, \$1.50, issued to residents between 14 and 18 years of age and authorizes hunting or angling in county of residence and adjoining counties. License issued by county clerks and duly appointed agents throughout the State. Guide, \$3 (issued only to citizens of United States); taxidermist, \$5; issued by commission. Licenses not issued to persons under 14. Owner and member of his family may hunt, trap, or fish on own premises without license during open season. Licenses, good for life, issued free of charge by State game commission to pioneers of State who arrived prior to 1870, veterans of Indian and Civil Wars, residents of State Soldiers' Home and disabled veterans of World War. Unlawful to hunt on inclosed or occupied land of another without permission of owner. Unlawful to shoot from highway or railroad right of ways, or within cemeteries or incorporated towns.

Bag limits and possession: Two black-tailed, or 1 black-tailed and 1 mule deer a season; 5 silver-gray squirrels in 7 consecutive days; 10 quail in 7 consecutive days in district 1; 4 quail a day, 8 in 7 consecutive days in district 2; 4 in all of ruffed grouse, pheasants, sooty or blue grouse and west of Cascades, Chinese pheasants, a day, 8 in 7 consecutive days, but a bag of 8 shall not include more than 1 Chinese pheasant hen, but east of Cascades Chinese pheasants have a separate limit of 4 a day, 8 in 7 consecutive days, but not more than 1 hen may be taken in 7 consecutive days; 4 Hungarian partridges a day, 8 in 7 consecutive days, 15 in all of ducks, Wilson's snipe, rails, coots, and gallinules a day, 20 in 7 consecutive days; 4 geese a day, 28 in 7 consecutive days, but not more than 30 ducks and 8 geese may be possessed at any one time.

⁷³ Unlawful to kill geese or other wild bird or animal at any time on islands or sand bars or within one-fourth mile of high-water line on Columbia east of eastern entrance of Celilo Canal or on islands and sand bars in Deschutes and John Day Rivers from Columbia River to point half a mile south of Oregon Trail highway bridges where the highway crosses said rivers, respectively.

Migratory game birds properly tagged may be possessed during first 10 days of close season; other game, when properly tagged, during close season.

Interstate transportation: Export of all protected game prohibited, except when tagged with metal seal and accompanied by permit from State warden showing kind of game and names and addresses of consignor and consignee.

Game taken outside of State and legally exported may be imported and possessed as authorized by permit and tag (fee, 5 cents) obtained from State game warden, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Sale: Sale of all protected game prohibited. Commission may make regulations permitting sale of game except migratory birds.

PENNSYLVANIA

Open seasons: ⁷³

Dates inclusive

Deer (male, with 2 or more points to 1 antler), bull elk (with 4 or more points to 1 antler)	Dec. 1-Dec. 15. ⁷⁴
Bear (over 1 year old)	Nov. 1-Dec. 15. ⁷⁴
Raccoon	Nov. 1-Jan. 15.
Hare, rabbit, squirrel (black, gray, fox), quail	Nov. 1-Nov. 30.
Red or pine squirrel	Nov. 1-Aug. 15.
Ruffed grouse	Nov. 1-Nov. 8.
Male ring-necked pheasant, wild turkey (see exception)	Nov. 1-Nov. 15.
<i>Exception:</i> Wild turkey in Fayette, Somerset, and Westmoreland Counties (1931).	
Blackbird	Aug. 1-Nov. 30.
Woodcock, Wilson's snipe	Oct. 15-Nov. 14.
Duck, goose, brant, coot	Oct. 1-Jan. 15.
Rail, other than coot and gallinule	Sept. 1-Nov. 30.
Gallinule	Oct. 1-Nov. 30.

No open season: Cow elk and calves having less than 4 points to one antler; does, fawns, bear cubs under 1 year of age; Hungarian partridges; pheasant hens, doves, swans, wood duck, elder ducks, reedbirds, auks, bitterns, little brown and sand-hill cranes, grebes, guillemots, gulls, herons, jagers, loons, murrets, petrels, puffins, shearwaters, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting and fishing licenses: *Game:* Nonresident, \$15. Issued by county treasurer or department of revenue. Resident, \$2. Licenses not issued to minors under 14, and minors between 14 and 16 must furnish written consent of parent or guardian. Licensee required to wear tag displayed on middle of back.

Resident citizen and members of family or employees residing upon and cultivating land in State as either owner or lessee may hunt during open season on such land and with consent of owner, on adjoining land without a license. Taxidermist license, fee \$1.

Licensed hunters, within 30 days after expiration of license, must report amount of game killed. Aliens not permitted to hunt or be possessed of dogs or firearms.

Fishing: Nonresident pays same fee charged nonresident by State where applicant resides, but not less than \$2.50 (10 cents extra to county treasurer); issued by county treasurer or department of revenue.

Resident, \$1.50 (10 cents extra to county treasurer); issued by county treasurer or department of revenue. License not required of minors under 16. Persons and members of family who reside upon their own farms or other lands throughout the entire year may angle in waters on or adjacent thereto during open season without license.

Bag limits and possession: One deer a day or season (6 to hunting party); 1 bear a day or season

⁷³ *Pennsylvania:* Seasons may be extended, closed, or shortened and bag limits reduced by commission.

⁷⁴ In killing deer, elk, or bears, only one all-lead, lead-alloy, soft-nosed, or expanding bullet may be used at each discharge. The use of steel-jacketed bullets is prohibited. Bow and arrow may be used.

(4 to hunting party); 5 rabbits a day, 30 a season; 6 squirrels (black, gray, fox) a day, 20 a season; 8 quail a day, 25 a season; 2 pheasant a day, 6 a season; 1 wild turkey a day or season; 4 woodcock a day, 20 a season; 20 jacksnipe a day; 15 ducks a day, 60 a season, 30 in possession; 4 geese a day, 30 a season, 8 in possession; 5 brant a day, 30 a season; 15 rails, 15 gallinules, 25 coot a day. Possession of migratory game birds permitted during season and first 10 days of close season; other game first 30 days of close season.

Interstate transportation: Export of all protected game taken in State prohibited; provided, a nonresident licensee may take out with him on same conveyance 2 days' limit of game except elk. Small game must be accompanied by owner and if concealed must be tagged to show name and address of owner, county where killed, and number of each species in package. Large game may be shipped by express when plainly marked to show name and address of owner and county in which killed. Specimens and trophies of game legally taken may be shipped by parcel post or otherwise to a licensed taxidermist for mounting, if marked to show contents, but no such shipments may be made to points outside the State without a permit. Skins of bears or raccoons may be shipped out of State by parcel post or otherwise if package is marked to show contents.

Game taken outside of State and legally exported may be possessed at any time, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Sale: Sale prohibited of wild deer and rabbits taken in the State, and of all other game wherever taken. Trophies of game not killed in State and skins of bears and raccoons wherever taken may be purchased or sold at any time.

Miscellaneous: Automatic gun prohibited.

Resident licensee may take deer without antlers (except fawns) November 27-29 under special deer license (fee, \$2 except on own land), in counties opened by commission, to prevent damage to property.

RHODE ISLAND

Open seasons:	Dates inclusive
Gray squirrel, hare, rabbit.....	Nov. 1-Dec. 31.
Quail or bobwhite, ruffed grouse or partridge, cock pheasant (see exceptions)...	Nov. 1-Dec. 31.
Exceptions: Cock pheasants in town of New Shoreham (4 days only), Oct. 15, Nov. 5 and 19, and Dec. 3, and in town of Jamestown (2 days only), Nov. 3 and 10.	
Duck, goose, brant, coot.....	Oct. 1-Jan. 15.
Wilson's snipe.....	Oct. 1-Nov. 30.
Woodcock.....	Nov. 1-Nov. 19.
Rail and gallinule, other than coot.....	Sept. 1-Nov. 30.

No open season: Deer,⁷⁵ doves, Hungarian partridges, hen pheasants, swans, wood duck, elder ducks, auks, bitterns, little brown and sand-hill cranes, gannets, grebes, guillemots, gulls, herons, jaegers, loons, murrets, petrels, shearwaters, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident: Game, \$10.25; fish, \$2.50.⁷⁶ Alien: Game, \$15.25; fish, \$2.50, alien resident for 1 year; \$5, alien, not resident for 1 year. Resident: Game, \$2.25; fish, \$1.25. Issued by city and town clerks. Fishing license not required of women, nor of males under 18. License not required of resident or his immediate family to hunt on own or leased agricultural lands on which actually domiciled; nonresident owning real estate valued at not less than \$500, and nonresident member or guest of club incorporated for hunting or fishing purposes prior to

Jan. 1, 1909, which owns real estate assessed for taxation at value of not less than \$1,000, may procure license at a fee of \$2.25; licenses not issued to minors under 15. Consent of owner required for hunting upland game birds on land of another from December 14 to October 15.

Bag limits and possession: Two ruffed grouse or partridges, 3 cock pheasants (except 2 a day in towns of New Shoreham and Jamestown); 6 quail, 15 ducks, 4 geese, 8 brant, 4 woodcock, 15 Wilson's snipe, 15 coots, 15 rails, 25 in all of rails and gallinules a day, but not more than 15 of any one species of gallinules, and not more than 15 game birds of all kinds, of which not more than 8 may be wild geese, in possession at one time. Possession of waterfowl, coots, and gallinules permitted during first 10 days of close season.

Interstate transportation: Export of all game prohibited; provided, a nonresident licensee may take out under his license 10 wild fowl or birds in one calendar year, if carried open to view.

Game taken outside of State and legally exported may be imported and possessed as authorized by permit from commissioners of birds, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Sale: Sale of all game birds prohibited.

Miscellaneous: Unlawful to import live game birds or animals except under permit.

SOUTH CAROLINA

Open seasons: ⁷⁷	Dates inclusive
Deer ⁷⁷ (male only) (see exceptions).....	Aug. 15-Jan. 1.
Exceptions: In Greenville, Oconee, and Pickens Counties (one day only). In Lexington, Richland, and Saluda Counties....	Jan. 1, 1931.
Bear.....	No open season.
Raccoon, opossum, fox.....	No close season.
Rabbit, ⁷⁸ squirrel ⁷⁸ (see exceptions).....	Sept. 1-Mar. 1. ⁷⁹
Exceptions: In Cherokee County, squirrel.....	Nov. 27-Feb. 1.
In Darlington County, squirrel.....	Sept. 16-Feb. 1.
In York County, squirrel.....	Nov. 1-Mar. 1.
In Oconee County, fox squirrel (one day only)....	Jan. 1, 1931.
Wild turkey (see exceptions)....	Nov. 27-Mar. 1. ⁷⁹
Exceptions: In Cherokee County.....	Nov. 27-Feb. 1.
In Greenville County (one day only).....	Jan. 1, 1931.
In Lancaster County.....	Nov. 27-Feb. 15.
Partridge (quail) (see exceptions).....	Nov. 27-Mar. 1. ⁷⁹
Exceptions: In Bamberg County.....	Nov. 27-Feb. 5.
In Cherokee, Chester, Fairfield, Greenville, and York Counties.....	Nov. 27-Feb. 1.
In Darlington and Pickens Counties (also Nov. 27 and 28 in Pickens County).....	Dec. 24-Mar. 1.
In Edgefield, Lancaster, Newberry, and Saluda Counties.....	Nov. 27-Feb. 15.
Blackbird (see exception).....	Nov. 27-Mar. 1.
Exception: In Lancaster County.....	Nov. 27-Feb. 15.

⁷⁷ South Carolina: Chief game warden of State may close seasons for periods not exceeding 10 days at one time on any waters or swamps of State when necessary to protect deer or other game on account of floods or other abnormal conditions; and on recommendation of any county legislative delegation may shorten season on any kind of game.

⁷⁸ Between Sept. 1 and Thanksgiving Day rabbits may be hunted without firearms, and squirrels may be hunted without dogs, except in Oconee and York Counties, only squirrels may be hunted without dogs from Nov. 1 to Thanksgiving Day.

⁷⁹ Season opens on Thanksgiving Day except as otherwise indicated.

⁷⁵ Rhode Island: Deer injuring crops may be killed at any time by owner or occupant of premises under written permit from secretary of state. Any person killing or wounding a deer must report within 24 hours to commissioners of birds.

⁷⁶ Fee required of nonresident angler equal to that required of nonresident in his State of residence.

Open seasons—Continued.		Dates inclusive
Mourning dove.....		(Sept. 1-Sept. 30. [Nov. 20-Jan. 31.
Woodcock.....		Dec. 1-Dec. 31.
Duck, goose, brant, coot, Wilson's snipe or jacksnipe.....		Nov. 1-Jan. 31.
Rail and gallinule (other than coot).....		Sept. 1-Nov. 30.

No open season: Does, ruffed grouse (pheasants), swans, wood duck, reedbirds, auks, bitterns, little brown, sand-hill, and whooping cranes, gannets, grebes, gulls, herons, jaegers, loons, murrets, petrels, shearwaters, terns, and all shore birds (except woodcock and Wilson's snipe or jack-snipe).

Hunting and fishing licenses: Nonresident: Game, \$15.25; fish, \$10.25. Issued by county game warden. Resident: Game, State, \$3.10; county of residence, \$1.10. Issued by county game warden and his agents.

No license required of resident owners, tenants, their children, or, under written permission, their employees, to hunt during open season on own lands. Confederate veteran wearing his cross of honor may hunt and fish in any county of State without license.

Consent of owner or manager required to hunt on land of another.

Hunting clubs and game preserves must register with chief game warden of State, file list of members including names and addresses, and during March of each year report number and kind of game killed by members during season.

Bag limits and possession: Five deer, 20 wild turkeys a season; 15 squirrels, 15 quail (partridges), 2 turkeys, 25 doves, 15 ducks, 4 geese, 8 brant, 4 woodcock, 20 Wilson's snipe, 25 coots, 25 sora, and 25 in all of other rails and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules a day. Not more than 30 ducks and 8 geese may be possessed at any one time. Possession of migratory birds permitted during first 10 days of close season.

Interstate transportation: Export of all resident nonmigratory game taken in State prohibited, except that a land owner or licensee may export under shipping tag from chief game warden of State one day's bag limit of resident nonmigratory game a week, if not for sale. Unlawful for any transportation company to receive for shipment out of the State any deer or other resident nonmigratory game unless duly tagged. Under Federal regulations not more than two days' limit of migratory birds may be taken or shipped out of the State in any one calendar week. All packages containing migratory birds must be marked to show actual contents and names and addresses of consignor and consignee. No game may be removed from the State for sale.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale prohibited of deer, quail (partridges), doves, wild turkeys, reedbirds, and all other migratory birds.

Miscellaneous: Game may not be kept in cold-storage or refrigerating plant except in private dwelling.

SOUTH DAKOTA

Open seasons:		Dates inclusive
Deer (male with visible horns), in Meade, Lawrence, Pennington, Custer, and Fall River Counties only.....		Nov. 1-Nov. 20.
Duck, goose, brant, coot, Wilson's snipe.....		Sept. 16-Dec. 31.
Rail and gallinule, other than coot.....		Sept. 16-Nov. 30.

No open season: Deer, except as above, elk, antelope, mountain sheep, quail, Hungarian partridges, doves, partridges or ruffed grouse, prairie chickens or pinnated grouse, white-breasted or sharp-tailed grouse, sage grouse, introduced pheasants⁸⁰ upland plover, woodcock, swans,

⁸⁰ *South Dakota:* Chinese, ring-necked, or English pheasants, partridges or ruffed grouse, prairie chickens or pinnated grouse, white-breasted or sharp-tailed grouse, and sage grouse may be taken and shipped under regulations of game and fish commission, Pierre.

wood duck, eider ducks, bitterns, little brown, sand-hill, and whooping cranes, grebes, gulls, heron, loons, shearwaters, terns, and all shore birds (except Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident or alien: Big game, \$25; small game, \$25; fish, \$2. Issued by game warden or county treasurer. Resident: Big game, \$5; small game and fish, \$1; issued by county treasurer, game and fish commission, and deputies; special license, small game, \$3 (hunting; also authorizes shipment of 50 birds in the State as specified in license); issued by game and fish commission. Fishing license not required of resident women, or of resident males under 18. Hunting and fishing license not issued to persons under 15 unless applied for by parent or guardian. Hunting game birds during open season on own land permitted without license. Unlawful to hunt on land of another without permission of owner or lessee. Taxidermist, \$2.

Bag limits and possession: One deer a year; 15 ducks, Wilson's snipe, coots, gallinules, sora, and other rails in the aggregate of all kinds a day, 30 in all in possession; 5 geese and brant, but not more than 4 geese, a day; 10 geese and brant, but not more than 8 geese, in possession at any one time. Possession permitted during open season and 5 days thereafter.

Interstate transportation: Export of all protected game prohibited; provided, a nonresident may, under permit of the game and fish commission, export 1 deer lawfully killed, and not more than 5 upland nonmigratory birds under each of 5 of the coupons, and not more than 5 migratory game birds under each of 5 of the coupons attached to his nonresident license; but not more than 8 geese, 10 brant, or 10 in the aggregate of geese and brant may be exported by one person in any one calendar week, and if exported by common carrier or as personal baggage tags attached to hunting license must be affixed to each shipment.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of all protected game prohibited; provided skins, heads, and antlers of deer lawfully killed may be sold.

TENNESSEE

Open seasons:		Dates inclusive
Deer, male, with horns having 2 or more spikes each (see exception).....		Dec. 20-Dec. 31.
Exception: In Carter, Cheatham, Johnson, Sullivan, and Unicoi Counties.....		No open season. June 1-Jan. 1.
Squirrel (see exceptions). Exceptions: In Carter, Greene, Unicoi, and Washington Counties.....		Aug. 1-Jan. 1.
In Decatur County (also May 1-Aug. 1).....		Oct. 1-Feb. 1.
In Cannon and Wilson Counties.....		No close season.
Rabbit (see exceptions).....		No close season.
Exceptions: In Carter County In Cooke, Davidson, Hamilton, Hardin, Hawkins, Jefferson, Johnson, Lawrence, and Sullivan Counties.....		Nov. 15-Feb. 15. Nov. 25-Feb. 1.
In Crockett County.....		Oct. 25-Mar. 1.
In Hardeman County.....		Nov. 24-Feb. 1.
In Madison County.....		Dec. 10-Feb. 14.
In McNairy County.....		Nov. 1-Feb. 1.
In Williamson County.....		Nov. 25-Feb. 1.
Quail or partridge (see exceptions).....		Nov. 25-Feb. 1.
Exceptions: In Carter County In Decatur County.....		Dec. 10-Feb. 20.
In Fayette County.....		Dec. 10-Feb. 15.
In Lauderdale County.....		Nov. 24-Feb. 1.
In Hardeman and Madison Counties.....		Dec. 10-Feb. 1.
In Hardin County.....		Dec. 10-Feb. 14.
In Haywood County.....		Dec. 20-Feb. 15.
In McNairy County.....		Nov. 15-Jan. 31.
In Robertson County.....		Nov. 25-Jan. 1.
In Sullivan County.....		Nov. 25-Jan. 15.
In Washington County.....		No open season.
In Claiborne County.....		No open season.

Open seasons—Continued.	Dates inclusive
Pheasant, in Carter, Greene, Unicol, and Washington Counties only.....	Nov. 20-Dec. 20.
Wild turkey (see exception).....	Nov. 15-Jan. 1.
Exception: In Carter, Greene, Unicol, and Washington Counties.....	No open season.
Duck, goose, brant, coot, mudhen, Wilson's snipe or jack-snipe.....	Nov. 1-Jan. 31.
Dove (see exceptions).....	Sept. 1-Dec. 15.
Exceptions: In Carter County In Claiborne County.....	Nov. 15-Dec. 15. No open season.
Rail, other than coot and gallinule.....	Sept. 1-Nov. 30.
Gallinule.....	Nov. 1-Nov. 30.

No open season: Does and fawns; grouse, ring-necked and Mongolian pheasants, woodcock, swans, wood duck, bitterns, sand-hill and whooping cranes, grebes, gulls, herons, loons, terns, and all shore birds (except Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident. Game, \$15 (may hunt on own land without license); fish, \$2.50. Resident, State, \$2 (resident must hold State license to hunt on Reelfoot Lake); county, \$1 (county licensee may obtain State license for \$1). Issued by county clerks. Licensee required to wear license tag displayed in center of back of outer garment.

Owners and tenants may hunt without license on land on which they reside. Unlawful to hunt on tillable or inclosed lands of another without permission.

Reelfoot Lake.—Guide or pusher, \$1 (issued to residents only).

Bag limits and possession: Two deer a season; 3 wild turkeys, 15 quail, 20 other game birds or animals a day, but not more than 4 geese, 8 brant, 15 ducks, 15 of any one species of rails (other than sora) and gallinules a day. Not more than 30 ducks and 8 geese may be possessed at any one time.

Reelfoot Lake.—Fifteen ducks, 4 geese, 8 brant, 20 Wilson's snipe, 20 in all of rails, coots, and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules, but not more than 20 in all of game birds a day.

Interstate transportation: Export of all protected game prohibited; provided, nonresident licensee may take out of State, if carried openly, game birds legally killed by him (except that 25 birds only may be exported from Reelfoot Lake), but not more than 30 ducks, 8 geese, 16 brant, 40 Wilson's snipe, 50 coots, 50 sora, 50 in all of rails and gallinules, but not more than 30 of any one species of rails (other than sora) and gallinules, and 50 doves may be exported by one person in any one calendar week.

No restrictions on export of rabbits except in counties where protected.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of all protected game (except rabbits) killed in State prohibited.

TEXAS

Open seasons:	Dates inclusive
Deer (male, with pronged horn) ⁸¹ (see exceptions), bear.....	Nov. 16-Dec. 31.
Exceptions: Black-tailed deer (male, with pronged horn), west of Pecos River.....	Nov. 16-Nov. 30.
Deer, in Bastrop, Callahan, Eastland, Harrison, Hemphill, Hutchinson, Palo Pinto, Parker, Roberts, San Saba, and Stephens Counties (1934).....	No open season.
Squirrel (see exceptions).....	May 1-July 31. Oct. 1-Jan. 31.

Open seasons—Continued.	Dates inclusive
Squirrel—Continued.	
Exceptions: In Angelina, Chambers, Cherokee, Hardin, Jasper, Jefferson, Liberty, Nacogdoches, Newton, Orange, Panola, Polk, Rusk, Sabine, San Augustine, San Jacinto, San Patricio, Shelby, Trinity, Tyler, and Walker Counties.....	Nov. 1-Jan. 31.
In Morris and Smith Counties.....	May 1-July 31. Nov. 1-Jan. 31.
In Austin, Bandera, Bastrop, Bell, Blanco, Bosque, Brazoria, Brown, Burnet, Caldwell, Callahan, Colorado, Comal, Comanche, Concho, Cook, Coryell, De Witt, Dimmit, Eastland, Edwards, Erath, Fayette, Fort Bend, Gillespie, Goliad, Gonzales, Guadalupe, Hamilton, Hays, Hill, Hood, Irion, Jackson, Karnes, Kendall, Kerr, Kimble, Lampasas, Lavaca, Llano, Mason, McCulloch, Matagorda, Medina, Menard, Mills, Montague, Real, San Saba, Schleicher, Stephens, Sterling, Tarrant, Throckmorton, Tom Green, Travis, Uvalde, Victoria, Waller, Washington, Wharton, Williamson, Wilson, Wise, and Zavalla Counties.....	No close season.
Quail or partridge, chachalaca or Mexican pheasant (see exception).....	Dec. 1-Jan. 16.
Exception: Quail, in Stephens County.....	No open season.
Prairie chicken or pinnated grouse (see exception).....	Sept. 1-Sept. 4.
Exception: In Collingsworth and Wheeler Counties.....	June 15, 1931.
Wild-turkey gobblers (see exceptions).....	Nov. 16-Dec. 31.
Exceptions: In Angelina, Bastrop, Brazos, Burleson, Cherokee, Grimes, Houston, Jasper, Lee, Leon, Madison, Montgomery, Nacogdoches, Newton, Polk, Robertson, Sabine, San Augustine, San Jacinto, Trinity, Tyler, Walker, and Washington Counties.....	Mar. 1-Apr. 30.
In Callahan, Eastland, Harrison, Palo Pinto, San Saba, Shackelford, and Stephens Counties.....	No open season.
Mourning dove, in north zone.....	Sept. 1-Oct. 31. ⁸²
In south zone.....	Oct. 1-Nov. 30. ⁸²

⁸² North and south zones divided by line running approximately from Rio Grande River east through Del Rio, thence following center of main track of Southern Pacific Railroad through Spofford, Uvalde, and Hondo to San Antonio; thence following International & Great Northern Railroad to Austin; thence along Houston & Texas Central Railroad through Elgin, Giddings, and Brenham to Brazos River; thence with center of Brazos River to Beaumont branch of Santa Fe Railway; thence following Gulf, Colorado & Santa Fe Railroad through Navasota, Montgomery, and Conroe to Cleveland; thence along Houston, East & West Texas Railroad to point where it strikes Louisiana line. For detailed boundary line see Service and Regulatory Announcements—B. S. No. 72, obtainable from Department of Agriculture, Washington, D. C., or State game law to be had from game, fish, and oyster commission, Austin, Tex.

⁸¹ Texas: Unlawful to kill deer with less than 8-point antlers in Frio, La Salle, Live Oak, and McMullen Counties.

Open seasons—Continued.

Dates inclusive

Aug. 8-Oct. 31.

White-winged dove.....
Duck, goose, brant, Wilson's
snipe or jacksnipe, coot, in
north zone.....
In south zone.....
Rail, other than coot and gal-
linule.....
Gallinule, in north zone.....
In south zone.....

Oct. 1-Jan. 31.⁸²

Nov. 1-Jan. 31.⁸²

Sept. 1-Oct. 31.

Oct. 16-Nov. 30.

Nov. 1-Nov. 30.

No open season: Does, fawns, spike bucks, ante-
lope, mountain sheep, turkey hens, robins, pheas-
ants (except chachalacas), reedbirds (rice birds),
woodcock, swans, wood duck bitterns, little
brown, sand-hill, and whooping cranes, gannets,
grebes, gulls, herons, jaegers, loons, petrels, band-
tailed pigeons, terns, and all shore birds (except
Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident or
alien: Game, \$25; fish (artificial lure), \$5, non-
resident, 5-day license, \$1.10. Resident citizen:
Game, \$2; not required in county of residence;
fish (artificial lure), \$1.10; issued by commissioner,
deputies, and county clerks. Boat (carrying
hunters), \$2; club or shooting preserve, \$5. Iss-
ued by commission. Manager of club or shoot-
ing preserve must keep record, require guests to
register number of game killed, and make com-
plete report to commission by Feb. 10 of each
year. Hunting license not required of persons
under 17. License does not entitle holder to hunt
on inclosed and posted lands of another without
consent of owner or agent.

Bag limits and possession: Two deer (west of
Pecos River, 1 blacktail), 1 bear, 3 turkey gobblers
a season; 10 squirrelr a day; 12 in all of quail and
chachalacas a day, 36 in 7 days, 36 of each in pos-
session; in Wood County, 8 a day, 24 in 7 days;
10 prairie chickens a day or season; 15 doves and
white wings a day, 45 in 7 days or in possession; in
Wood County, 10 a day, 30 in 7 days; 25 in all of
ducks, rails, coots, gallinules, and Wilson's snipe
a day, but not more than 20 Wilson snipe, 15
ducks, or 15 of any one species of rails (other than
sora) and gallinules a day, 50 in all in 7 days; 4
geese and brant a day, 12 in 7 days, but not more
than 25 in all of waterfowl, rails, coots, gallinules,
and jacksnipe a day, and not more than 50 game
birds of all kinds in 7 days or in possession, except
that not more than 30 ducks and 8 geese may be
possessed at any one time. Possession of all game
permitted during open season and 10 days there-
after.

Interstate transportation: Export prohibited of
all game, except that nonresident licensee may
ship game lawfully possessed to his home for own
use under affidavit (fee, 25 cents) that it was law-
fully killed and will not be bartered or sold; pro-
vided that not more than two days' limit of mi-
gratory birds may be exported in any one calen-
dar week. Game may be shipped to taxidermist
for mounting under affidavit that shipper killed
the specimen and that it is not being preserved
for sale.

Game taken outside the State and legally ex-
ported may be possessed in like manner as game
taken in State.

Sale: Sale prohibited of all protected game.

UTAH

Dates inclusive

Open seasons:⁸³
Deer (buck, with horns not less
than 5 inches long)⁸⁴.....
Bear, rabbit, hare.....
Duck, goose, brant, coot, Wil-
son's snipe or jacksnipe (see
exceptions).....
Exceptions: In Beaver, Em-
ery, Grand, Iron, Kane,
Millard, Morgan, Rich,
San Juan, Sevier, Sum-
mit, Uintah, Wasatch,
and Washington Coun-
ties.....
Duck, in Fish Lake Game
Preserve.....

Oct. 20-Oct. 30.

No close season.

Oct. 1-Dec. 31.

Oct. 1-Jan. 15.

Oct. 1-Nov. 30.

No open season: Does, fawns, elk,⁸⁵ antelope,
mountain sheep, mountain goats, quail, any
species of grouse or sage hens, Hungarian par-
tridges, mourning doves,⁸⁶ swans, wood duck,
rail, gallinules, bitterns, sand-hill cranes, grebes,
gulls, herons, loons, band-tailed pigeons, terns,
and all shore birds (except Wilson's snipe or
jacksnipe).

Hunting and fishing licenses: Nonresident
citizen: Small game and fish, \$10; deer and bear,
\$15; fish, \$3. Resident citizen (male): Game and
fish, 12 to 16 years, \$1; 16 and over, \$3; game, \$2;
fish, \$2; females, 16 and over, game and fish, \$1.
Alien: Fish, \$7.50. Guide, \$5 (resident only).
Aliens prohibited from hunting in State or owning
firearm. Resident citizens, males under 12, and
females under 16, not required to obtain licenses
to fish. Issued by State fish and game commis-
sioner or deputy, county clerk, or deputy or
authorized agent.

Bag limits and possession: One buck a season;
25 ducks, geese, brant, Wilson's snipe, coots, and
gallinules a day, but not more than 15 ducks,
4 geese or 8 brant; 15 Wilson's snipe or more than
15 of any one species of gallinules a day. Not
more than 25 game birds in all may be taken in
one day; 50 in all of game birds in possession at any
one time, but not more than 30 ducks and 8 geese
may be possessed at any one time.

Interstate transportation: Export of all game
prohibited, except under permit and regulations
of commissioner.

Game taken outside of State and legally exported
may be possessed at any time, except that mi-
gratory game birds may be possessed only during
open season where taken and first 10 days of close
season. Persons possessing game during close
season in State must show lawful taking.

Sale: Sale of all game prohibited; except that
rabbits, bears, and hides of deer legally killed may
be sold.

VERMONT

Open seasons:

Dates inclusive

Deer (with horns not less than
3 inches long) ⁸⁷ (see excep-
tion).....

Nov. 10-Nov. 20.

Exception: In Franklin
County.....

Jan. 1, 1932.

Hare, rabbit.....

Oct. 1-Feb. 28.

Gray squirrel, woodcock.....

Oct. 1-Oct. 31.

Quail.....

Sept. 15-Nov. 30.

Duck (see exception), goose,
brant, coot.....

Sept. 16-Dec. 31.

Exception: Ducks on waters
or shores of Joes Pond in
towns of Danville, Cabot,
and Walden, Stone Pond or
Shadow Lake in town of
Glover, Caspian Lake in
town of Greensboro, and
Grotton or Lunds Pond in
town of Grotton (1937).

English or Wilson's snipe (jack-
snipe), gallinule.....

Sept. 16-Nov. 30.

No open season: Elk, moose, caribou (1932); does,
fawns, doves, rail; pheasants, European partridges
(1932); ruffed grouse or partridges (1931); swans,
wood duck, auks, bitterns, sand-hill and whoop-
ing cranes, grebes, gulls, herons, jaegers, loons,
murrees, petrels, terns, and all shore birds (except
woodcock and Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident:
Game and fish, \$10.50; fish, \$3.15, but residents of
States or countries charging larger nonresident

⁸⁵ Elk doing damage may be killed under author-
ity of commissioner.

⁸⁶ Commissioner, upon determining that quail,
any species of grouse or sage hens, Hungarian par-
tridges, pheasants, or mourning doves have in-
creased sufficiently, may prescribe an open season
and fix bag limits on any such birds.

⁸⁷ Vermont: Landowner, member of his family, or
authorized employee may kill deer doing damage to
his fruit trees or crops; but person under whose di-
rection a deer is so killed must, within 12 hours,
report the matter in a signed statement to nearest fish
and game warden. Deer may also be killed at any
time in orchard zones established by commissioner,
but such killing must forthwith be reported to
owner of orchard and county warden.

⁸² See footnote on p. 32, col. 2.

⁸³ Utah: Commissioner may shorten or close open
season and reduce bag limit on any species of game
birds or animals needing additional protection.

⁸⁴ Person under 16 may not hunt deer.

angling license fee must pay fee charged nonresidents in own State or country. Resident: Game and fish, \$1.50; game, \$1; fish, \$1. Issued by town clerks. Citizen of United States who owns \$1,000 taxable property in Vermont pays same fees as resident. Alien resident who has not declared his intention, pays same fees as nonresident; declarant resident for six months in State pays same fees as resident.

Hunting licenses not issued to persons under 16 without written consent of parent or guardian. Owners of farm lands and their resident minor children or tenants may hunt and fish without a license on own lands during open season. Fishing license not required of persons under 15.

Bag limits and possession: One deer a season; 4 woodcock a day, 25 a season; 5 hares or rabbits a day or in possession; 4 gray squirrels a day or in possession; 4 quails a day, 12 ducks a day, 50 a season, 5 geese a season but not more than 4 a day; 3 brant; 10 Wilson's snipe a day; 25 coots, 25 gallinules but not more than 15 gallinules of any one species a day.

Possession of waterfowl, coots, and gallinules permitted during first 10 days of close season, but not more than 30 ducks and 5 geese may be possessed at any one time.

Interstate transportation: Export prohibited of all protected game, except hares and rabbits; provided, a nonresident licensee may export one deer under license coupon and one day's bag limit of game birds under permit, but must accompany shipment; resident may export (if not for sale) one day's bag limit of game birds under special permit from commissioner and one deer a season for sale, if it is tagged and license is presented to carrier for cancellation, but laws of State to which deer is shipped must be complied with. Packages containing game delivered to a common carrier for transportation must be tagged to show number and kind of such game therein, names of consignor and consignee, station from which shipped, destination, and number of license. License of shipper must be presented to agent of transportation company for indorsement thereon of quantity of game offered for transportation. Head, hides, feet, and fur of quadrupeds and plumage and skins of game birds legally killed and possessed may be transported without tags if accompanied by owner.

Game taken outside of State and legally exported may be possessed as authorized by permit obtained from fish and game commissioner, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Sale: Sale of squirrels and all protected game birds prohibited; deer may be sold during open season and for a "reasonable time thereafter," and hares and rabbits during open season. Head and hide of deer legally taken may be sold.

VIRGINIA

Open seasons: ⁸⁸	Dates inclusive
Deer (male, with horns visible above hair):	
East of Blue Ridge Mountains (see exceptions).....	Nov. 15-Dec. 31.
Exceptions: In Prince George County.....	Dec. 1-Jan. 15.
In Sussex County.....	Oct. 15-Jan. 1.
In Gloucester, King George, Lancaster, Northumberland, Richmond, Stafford, and Westmoreland Counties.....	No open season.
West of Blue Ridge Mountains (see exceptions).....	Nov. 15-Nov. 30.
Exceptions: In Bath County.....	Nov. 15-Nov. 20.
In Augusta, Bland, Grayson, Highland, Montgomery, Roanoke, Rockingham, Russell, Shenandoah, Smyth, Tazewell, Washington, and Wythe Counties.....	No open season.

Open seasons—Continued.	Dates inclusive
Elk ⁸⁹ (with horns visible above hair) (see exception).....	Dec. 15-Dec. 31.
Exception: Bull elk, in Bland, Craig, Giles, Montgomery, and Pulaski Counties (3 days).....	Dec. 1, 2, 3.
Black bear (adult).....	Nov. 15-Jan. 31.
Rabbit ⁹⁰ (see exceptions).....	Nov. 15-Jan. 31.
Exceptions: In Culpeper, Fairfax, Fauquier, Greene, Loudoun, Orange, Prince William, Rappahannock, and Stafford Counties.....	Nov. 15-Dec. 31.
West of Blue Ridge Mountains (except in Bath and Highland Counties).....	Nov. 15-Dec. 31.
In Bath County.....	Nov. 15-Nov. 30.
In Highland County.....	Nov. 15-Dec. 15.
Squirrel:	
East of Blue Ridge Mountains (see exceptions).....	Sept. 1-Sept. 30. (Nov. 15-Jan. 31.)
Exceptions: In Accomac and Northampton Counties	Dec. 1-Dec. 31.
In Appomattox, Buckingham, Chesterfield, Culpeper, Gloucester, Louisa, and Prince Edward Counties.....	Nov. 15-Jan. 31.
In Fairfax, Fauquier, Greene, Loudoun, Orange, Prince William, and Rappahannock Counties.....	Sept. 1-Sept. 30. (Nov. 15-Dec. 31.)
West of Blue Ridge Mountains (see exceptions).....	Sept. 1-Dec. 31.
Exceptions: In Alleghany County.....	Nov. 15-Dec. 31.
In Frederick County.....	Sept. 1-Oct. 15. (Nov. 15-Dec. 31.)
In Bath and Highland Counties.....	Nov. 15-Nov. 30.
Wild turkey, ruffed grouse, bobwhite quail (see exceptions).....	Nov. 15-Jan. 31.
Exceptions: In Culpeper, Fairfax, Fauquier, Greene, Loudoun, Orange, Prince William, Rappahannock, and Stafford Counties.....	Nov. 15-Dec. 31.
Turkey, in Albemarle, Franklin, Henry, Lancaster, Northumberland, Richmond, and Westmoreland Counties.....	No open season.
West of the Blue Ridge Mountains (see exceptions).....	Nov. 15-Dec. 31.
Exceptions: In Highland County.....	Nov. 15-Dec. 15.
Turkey, in Giles, Lee, Pulaski, Roanoke, Russell, Scott, Smyth, Tazewell, Washington, and Wise Counties.....	No open season.
Turkey, ruffed grouse, in Bath County.....	Nov. 15-Nov. 30.
Quail, in Bath County.....	Nov. 15-Dec. 15.
Woodcock.....	Sept. 1-Dec. 15.
Mourning dove.....	Sept. 1-Dec. 15.
Duck, goose, brant, coot, Wilson's snipe or jacksnipe.....	Nov. 1-Jan. 31. ⁹¹
Rail and gallinule (other than coot).....	Sept. 1-Nov. 30.
No open season: Does, fawns, Hungarian partridges, ring-necked, golden, and silver pheasants, swans, wood duck, elder ducks, reedbirds, auks, bitterns, sand-hill cranes, fulmars, gannets, grebes, gulls, herons, loons, murre, petrels,	

⁸⁸ Elk doing damage to crops or fruit trees may be killed at any time while actually on premises, but killing must be reported to game warden.

⁹⁰ Residents of State may kill rabbits or hares and squirrels on their own lands at any time.

⁹¹ Wild fowl may not be hunted on Wednesdays, Saturdays, or Sundays, on Back Bay, Princess Anne County, nor on Wednesdays, Thursdays, or Sundays elsewhere east of Blue Ridge Mountains.

⁸⁸ Virginia: Commission of game and inland fisheries may by regulation further restrict the time, manner, and means by which game may be taken.

shearwaters, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting, trapping, and fishing licenses (combined): Nonresident: \$15.50 (additional county certificates, fee \$2.50 for nonresidents, 50 cents for residents, required for bull elk in Bland, Craig, Giles, Montgomery, and Pulaski Counties); angling, \$5.⁹² Commissioned or enlisted members of Army, Navy, or Marines stationed or located in Virginia pay same fees as residents for hunting licenses. Alien: Game, \$15.50, angling, \$5 (alien owner of real estate resident for five years, same as resident). Resident: State, \$3; county, \$1; (county license or nonresident angling license may be exchanged by holder for State license or nonresident hunting, trapping, and fishing license, respectively, on payment of difference in cost plus a fee of 25 cents to issuing officer). Issued by clerks of circuit and corporation courts and designated agents. Licensee required to wear license button. Certificate in lieu of lost or destroyed license issued under affidavit and on payment of clerk fee of 25 cents.

Residents, nonresidents, and aliens and their husbands, wives, or children may hunt, trap, or fish on own premises and fish in waters bounding or adjoining own premises during open season without license; tenant, renter, or lessee, under written consent of owner or landlord, may hunt, trap, or fish during open season without license on premises on which he resides.

Fishing license required in all inland waters, including brackish and fresh-water streams, creeks, bays (including Back Bay), inlets, and ponds in the tidewater counties, but not required of any person under 16.

Written consent required to hunt or trap on lands of another. Does not apply to persons hunting foxes or deer with hounds or dogs, where the chase begins on other lands, nor on uninclosed mountain lands west of the Blue Ridge not used for cultivation, except in Alleghany, Bath, Bland, Craig, Giles, and Highland Counties, and mountains in western Rockingham County.

Special licenses, Back Bay, Princess Anne County: Battery, sinkbox, mat blind,⁹³ fee \$100 (limited to not more than 50 batteries and sinkboxes and 27 mat blinds actually used in 1927-28; any license not renewed each year may not be reissued until number of batteries and sinkboxes is less than 25 and that of mat blinds less than 11). Shore blind, \$50. Issued by clerk, circuit court, Princess Anne County.

Bag limits and possession: One elk a season; 1 deer a day, 2 a season; 10 each of squirrels and hares (rabbits) a day, 150 of each a season; 2 turkeys a day, 4 a season; 4 grouse a day, 20 a season; 15 quail a day, 150 a season; 25 doves a day, 250 a season; 4 woodcock a day, 25 a season; 15 ducks a day, 350 a season; 4 geese a day, 50 a season; 8 brant a day, 30 a season; 20 Wilson's snipe a day, 250 a season; 25 sora a day, 500 a season; 25 coots a day, 250 a season; 25 in all of rails (other than sora) and gallinules but not more than 15 of any one species a day, 250 a season. Possession permitted during open season and 10 days thereafter of game lawfully taken, but not more than 30 ducks and 8 geese may be possessed at any one time.

Interstate transportation: Export of all protected game (except rabbits and squirrels) prohibited; provided, during open season any licensee may, under his hunting license, take with him out of State, or as baggage on same conveyance, open to view, and plainly labeled with his name and address, not more than 2 days' limit of game lawfully taken by him. Any citizen of State may ship from State during open season as a gift and not for sale (which fact must be stated on

shipping tag) one day's bag limit in one calendar week, if open to view and plainly labeled with names and addresses of donor and donee and number and kind of each so shipped.

Game taken outside of State and legally exported may be possessed in like manner as game taken in State.

Sale: Sale of all game prohibited, except of rabbits and squirrels during open season.

WASHINGTON

Open seasons:⁹⁴

Dates inclusive

Deer (male), elk,⁹⁵ bear, rabbit, squirrel, and upland game birds, open seasons fixed by county game commissions.⁹⁴
Duck, goose, brant,⁹⁶ coot, Wilson's snipe or jacksnipe Oct. 1-Jan. 15.
Rail other than coot Sept. 1-Nov. 30.

No open season:⁹⁴ Moose, elk (except as above); does, fawns, antelope, caribou, mountain sheep, mountain goats, and doves; swans, wood duck, eider ducks, auklets, auks, bitterns, little brown and sand-hill cranes, fulmars, grebes, guillemots, gulls, herons, jaegers, loons, murrelets, petrels, band-tailed pigeons, puffins, shearwaters, terns, and all shore birds (except Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident citizen or declarant residing in State less than 6 months: State, \$25 (applicant from adjoining State pays same fees as charged resident of Washington by State of which he is a resident); game birds, \$5; fishing: State, \$5; county, \$2.50; tourist fishing, State, \$3 (valid for 30 days). Resident (includes declarant residing in State six months): State: Game and fish, \$7.50; fish, \$5; game and fish, county, \$1.50; guide, \$10; taxidermist, \$5. Resident special elk license (fee, \$5) (issued to holder of State or county hunting and fishing license): Nonresident, \$25 (issued to holder of State hunting and fishing license). Issued by county auditors. Alien: Hunting and fishing, State, \$25 (issued only to holder of permit to carry firearms); fishing, county, \$5. Professional guide (county), \$10. Licensee must report number of game, fish, and fur animals taken in previous year before renewal of license. Fishing license not required of residents under 16.

Bag limits and possession: One deer, 1 elk, a season; 5 each of ruffed grouse, blue grouse, and Chinese or Mongolian pheasants, 10 each of quail and Hungarian partridges, a day or in possession, but a person desiring to possess more than one day's limit of upland game birds may do so by having each day's kill tagged that day by a game warden, and such tagged birds may be possessed during close season. Tagging fee, 10 cents for each bird, animal, or fish. Twenty ducks, geese, brant, Wilson's snipe a week (week ends at midnight Saturday), but not more than 4 geese, 8 brant, or 15 ducks a day; 30 ducks, geese, and brant (but not more than 8 geese) in possession; 25 coots, 25 sora, and 25 in all of other rails and gallinules but not more than 15 of any one species of rails (other than sora) and gallinules a day. Possession during close season permitted upon filing with county game commission description and number of each kind of game, which must be tagged or stamped by commission for identification, but rails may only be possessed until December 10 and other migratory game birds until January 25.

Interstate transportation: Export of all protected game prohibited, except that nonresident

⁹² Residents of States having larger nonresident angling license fee must pay fee charged nonresidents in own State.

⁹³ Battery, sinkbox, mat blind, or other floating device, or any boat or tender thereof, may not anchor, tie-out, or lie within 700 yards (except in North Bay, 200 yards) of any licensed blind or any blind on shore not licensed that is at any time occupied by the owner, or member or guest of any club owning same, for shooting therefrom.

⁹⁴ Washington: County game commission, with consent of supervisor of game and game fish, may shorten, close, or open season and fix bag limits on game and fur animals and upland game birds, as designated by statute. Communicate with county game commission at county seat, or supervisor of game and game fish, Box 334, Seattle.

⁹⁵ Unlawful at all times to kill elk in Clallam, Jefferson, Grays Harbor, and Mason Counties.

⁹⁶ No open season on waterfowl on Columbia or Snake Rivers or within a quarter of a mile of their shores in Benton, Columbia, Douglas, Franklin, Garfield, Grant, Kittitas, Klickitat, Walla Walla, Whitman, and Yakima Counties.

licensee may carry with him one day's limit of game birds upon attaching an affidavit that they were lawfully killed by himself and are not being exported for sale.

Game taken outside of State when accompanied by affidavit of chief game official may be possessed at any time for noncommercial use, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Sale: Sale of all protected game prohibited.

WEST VIRGINIA⁹⁷

Open seasons: ⁹⁷	Dates inclusive
Deer (male, with branched horns) (see exception).....	Dec. 1-Dec. 10.
Exception: In Marion, Marshall, Mercer, and Mingo Counties.....	No open season.
Rabbit (except on own land, at any time).....	Oct. 15-Dec. 31.
Squirrel (except red squirrel, no close season).....	Sept. 16-Nov. 30. ⁹⁸
Raccoon, opossum.....	Nov. 1-Jan. 31.
Ruffed grouse (pheasant), wild turkey.....	Oct. 15-Nov. 30.
Quail (Virginia partridge).....	Nov. 1-Nov. 30.
Duck, goose, brant, coot, Wilson's snipe or jacksnipe.....	Sept. 16-Dec. 31.
Woodcock.....	Nov. 15-Dec. 15.
Rail (ortolan) and gallinule, other than coot.....	Sept. 1-Nov. 30.

No open season: Elk (1935); does and fawns; doves, imported pheasants, Hungarian partridges, capercaillie, and other introduced foreign game birds; swans, wood duck, bitterns, sand-hill cranes, grebes, gulls, herons, jaegers, loons, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident: Game, \$15; fish, \$5. Resident: Game and fish, \$1.25; resident, big game, \$5. Issued by county clerk. License tag must be displayed between the shoulders on outer garment of licensee. Killing of deer must be reported to commission within 20 days. Aliens not permitted to hunt or fish, or to possess firearms. License not required of minors under 15. Landowner, his resident children and tenants, may hunt or fish on own land during open season without license. Unlawful to hunt or fish on lands of another without written permission of owner.

Bag limits and possession: One deer a season; 1 wild turkey a day, 2 a season; 6 rabbits a day, 40 a season, except rabbits killed on own premises; 6 squirrels a day, 30 a season; 8 quail a day, 50 a season; 3 ruffed grouse a day, 15 a season; 15 ducks, 4 geese, 8 brant, 4 woodcock, 20 Wilson's snipe, 25 coots, 25 sora, and 25 in all of other rails and gallinules, but not more than 15 of any one species of rails (other than sora) and gallinules a day. Not more than 30 ducks and 8 geese may be possessed at any one time. Possession of migratory birds permitted during first 10 days of close season; other game legally taken may be possessed at any time.

Interstate transportation: Export prohibited of elk, deer, squirrels, quail, ruffed grouse (pheasant), wild turkeys, geese, brant, ducks, provided a nonresident licensee may personally take with him out of the State, during any open season, one day's limit of game animals or birds lawfully taken by himself.

Game taken outside of State and legally exported may be possessed at any time, except that migratory game birds may be possessed only during the open season where taken and first 10 days of close season.

Sale: Sale prohibited of all protected game except rabbits.

⁹⁷ West Virginia: Commission by order may change, modify, or suspend open season, or change the bag limit on any game.

⁹⁸ Commission, on petition of 150 licensed hunters in any county, may open squirrel season in such county not earlier than Sept. 1 and close season at a correspondingly earlier date.

WISCONSIN

Open seasons:	Dates inclusive
Deer (male, not less than 1 year old), in Pierce, Barron, Chippewa, Rusk, Price, Lincoln, Langlade, Oconto, and all counties north thereof (season closed in odd, open in even years)....	Dec. 1-Dec. 10.
In rest of State.....	No open season.
Rabbit (except in Crawford County, no close season)....	Nov. 1-Jan. 1.
Squirrel (see exception).....	Nov. 1-Jan. 1.

Exception: In Dodge, Fond du Lac, Jefferson, Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha Counties.....

No open season.

Duck,⁹⁹ goose, brant, coot,⁹⁹ or mud hen, Wilson's snipe or jacksnipe.....

Sept. 16-Dec. 20.

Rails and gallinules, other than coot.....

Sept. 16-Nov. 30.

No open season: Elk, moose, does and fawns, bear, quail, pheasants (Chinese, English, Mongolian); Hungarian partridges, prairie chickens or pinnated grouse, sharp-tailed grouse, partridges, spruce hens, doves, woodcock, swans, wood duck, elder ducks, auks, bitterns, little brown, sandhill, and whooping cranes, grebes, guillemots, gulls, herons, loons, murres, terns, and all shore birds (except Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident: All game, \$50; all game (except deer), \$25; fish, \$3 (3 shipping coupons, \$2 additional); fishing license not required of persons under 16; settler, \$1 (deer tag, 50 cents); guide, \$1. Issued by commission. Resident: Game, \$1 (deer tag, 50 cents additional); issued by county clerks.

Hunting licenses not issued to persons under 15 or to aliens. Hunting prohibited in fields of growing grain or on lands of another without consent of owner.

Bag limits and possession: One male deer in even years (1930); 5 squirrels a day; 5 rabbits a day (except in Crawford County, no limit); 4 geese, 8 brant a day. Ducks (including coot or mud hen), 15 a day; snipe, rail, rice hen, gallinule, 15 a day, but not more than 25 in all of rails (other than sora) and gallinules a day.

Possession at any time of deer duly tagged permitted for private use by person killing it.

Possession in excess of one day's bag limit prohibited.

Possession at any time prohibited of game by person without hunting license or scientist's certificate.

Interstate transportation: Export of all protected game prohibited, except that nonresident licensee may transport, between Dec. 1 and 10, inclusive (1930), 1 deer duly tagged, if he accompanies shipment and may take in his personal possession, openly, a mixed bag of not more than 20 game birds legally killed, but not more than the bag limit for one day or any one variety.

Game taken outside of State and legally exported may be possessed as authorized by permit from conservation commissioner, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season.

Sale: Sale of all protected game prohibited (except rabbit). Rabbits may be sold during open season.

WYOMING

Open seasons: ¹	Dates inclusive
Deer (male, with forked horns) (see exceptions).....	Sept. 15-Nov. 15.

⁹⁹ Wisconsin: Ducks and coots or mud hens may not be hunted on Wednesday of each week during open season.

¹ Wyoming: State game and fish commission may suspend open season in any county or district of State on any species of game when threatened with extinction.

Open seasons—Continued.	Dates inclusive
Deer—Continued.	
Exceptions: In Albany, Campbell, Carbon, Converse, Johnson, Natrona, Platte, Sheridan, and Sweetwater Counties.....	Oct. 1-Oct. 15.
In Hot Springs and Washakie Counties.....	Oct. 16-Oct. 30.
In Big Horn County.....	Nov. 1-Nov. 10.
In Goshen, Laramie, and Niobrara Counties.....	No open season.
In Lincoln, Sublette, and Uinta Counties.....	Oct. 1-Nov. 15.
In Crook and Weston Counties.....	Oct. 15-Nov. 15.
Elk (see exceptions).....	No open season.
Exceptions: In Albany and Carbon Counties.....	Oct. 1-Oct. 15.
In Big Horn County.....	Nov. 1-Nov. 10.
In Crook County.....	Oct. 15-Nov. 15.
In Fremont, Park, and Teton Counties.....	Sept. 15-Nov. 15.
In Johnson and Sheridan Counties.....	Oct. 15-Nov. 14.
In Lincoln, Sublette, Sweetwater, and Uinta Counties.....	Oct. 1-Nov. 15.
Bull moose ² (see exceptions).....	No open season.
Exceptions: In parts of Fremont, Park, and Teton Counties.....	Sept. 15-Nov. 15.
In parts of Lincoln and Sublette Counties.....	Oct. 1-Nov. 15.
Male mountain sheep (see exceptions).....	No open season.
Exceptions: In Fremont, Park, and Teton Counties.....	Sept. 15-Nov. 15.
In Lincoln and Sublette Counties.....	Oct. 1-Nov. 15.
Sage hen, or sage chicken (see exception).....	Aug. 16-Aug. 18.
Exception: In Carbon, Goshen, Laramie, Sheridan, and Teton Counties.....	No open season.
Grouse (see exceptions).....	No open season.
Exceptions: In Campbell, Crook, Platte, and Weston Counties.....	Sept. 1-Sept. 30.
In Fremont County.....	Sept. 15-Oct. 1.
In Johnson and Sheridan Counties.....	Oct. 1-Oct. 30.
In Lincoln, Sublette, and Sweetwater Counties.....	Oct. 1-Nov. 15.
In Park and Teton Counties.....	Sept. 15-Nov. 15.
Duck, goose, brant, coot, Wilson's snipe, or jacksnipe.....	Sept. 16-Dec. 16.
No open season: Antelope; buffalo; does and fawns; pheasants, quail, Hungarian partridges, prairie chickens (1939); doves, swans, wood duck, rails, gallinules, bitterns, little brown and sandhill cranes, grebes, gulls, herons, loons, terns, and all shore birds (except Wilson's snipe or jacksnipe).	

² Commission may issue not to exceed 50 permits for bull moose. Fees, resident citizen, \$50; non-resident or noncitizen, \$100; limit, 1 a season.

Hunting and fishing licenses: Nonresident: General hunting and fishing, \$60 (not issued to minors under 16); game birds, \$10 (not issued to minors under 16); fishing, \$4 (not issued to minors under 14). Nonresident hunting big game must be accompanied by a guide, except that two persons may accompany one guide. Nonresident special elk license, \$40 (not required where nonresident general license has been procured). Nonresident, special mountain sheep license, \$15. Nonresident special bear permits, \$25 (authorizes killing of 3 bears). Resident: General hunting and fishing, \$5 (not issued to minors under 16); game birds, \$2 (not issued to minors under 13); fishing, \$1.50 (not required of Civil War veterans or minors under 16). Resident, special elk and special deer licenses, \$2.50 each, and mountain sheep, \$5, but not required where general hunting and fishing licenses have been procured. Guide license, citizen only, \$25 (bond, \$500). Permit to photograph game or birds Jan. 1 to Apr. 30, inclusive, under supervision of commission, \$5. Taxidermist, \$10. Resident alien, fishing, \$7.50; resident alien, game bird, \$10. Nonresident alien, fishing, \$12.50. Alien licenses not issued to minors under 14. Hunting predatory animals or bears in national forests, fee \$1 for each dog. Licenses and permits issued by State game and fish commissioner, his chief assistant, chief clerk, assistant and deputy game and fish commissioners, superintendents of fish hatcheries, justices of the peace, and persons authorized by State game and fish commission. Unlawful to hunt on inclosed lands of another without permission.

Bag limits and possession: One deer, 1 elk, 1 mountain sheep, 1 bear a season; under special permits,¹ 1 bull moose, 1 antelope, 3 bears (nonresident), a season; possession limited to 15 game birds, of which not more than 6 may be sage hens, sage chickens, or grouse. Federal limits on killing migratory game birds: 15 ducks, 4 geese, 8 brant, 20 Wilson's or jacksnipe, 25 coots, a day. Not more than 30 ducks and 8 geese may be possessed at any one time.

Interstate transportation: Export of all protected game prohibited, provided game may be exported if properly tagged by a justice of peace, assistant or deputy commissioners, or superintendents of fish hatcheries; fee, 50 cents. Game tags issued under affidavit that game was lawfully killed, and, if for edible portion, that it is not for sale. Not more than 30 ducks, 8 geese, 16 brant, 40 Wilson's snipe; 50 coots or 50 in all of rails and gallinules but not more than 30 of any one species may be exported by one person in any one calendar week.

Game taken outside of State and legally exported may be possessed at any time, except that migratory game birds may be possessed only during open season where taken and first 10 days of close season. Person possessing game during close season in State must show lawful taking.

Sale: Sale of all game of State prohibited, except edible portion when properly tagged. Justices of the peace, assistant and deputy commissioners, or superintendents of fish hatcheries issue tags (fee, 50 cents) under affidavit of lawful killing. Sale of migratory birds prohibited.

CANADA

ALBERTA

Open seasons:	Dates inclusive
Deer (see exception), moose, caribou (must have horns at least 4 inches long).....	Nov. 1-Dec. 14. ³
Exceptions: Deer, south of North Saskatchewan River,	

³ Alberta: Seasons on game birds fixed by lieutenant governor in council and may be obtained from game commissioner, Edmonton.

⁴ Resident north of fifty-fifth parallel, when necessary to provide food for his family, may kill big game (other than buffalo and elk) and scoters.

⁵ Deer, moose, and caribou (big game must have horns at least 4 inches long), open season under special license in Rocky Mountain Forest Reserves of Alberta, Sept. 1 to Oct. 31, inclusive (see Hunting licenses).

Open seasons—Continued.	Dates inclusive
Deer—Continued.	
and east of Canadian Pacific Railway from Edmonton to Macleod.....	No open season.
Mountain sheep (male), mountain goat (must have horns at least 4 inches long).....	Sept. 1-Oct. 31.
Bear (except cubs or bear with cub).....	Sept. 1-June 14.
Sharp-tailed grouse, north of Red Deer River only.....	Oct. 1-Oct. 15.
European gray partridge (Hungarian partridge).....	Oct. 1-Nov. 15.
Duck, goose, Wilson's snipe or jacksnipe, coot, gallinule: North of Clearwater and Athabaska Rivers.....	Sept. 1-Dec. 14.
South.....	Sept. 15-Dec. 14.

No open season: Antelope, elk or wapiti, buffalo; females of deer, moose, mountain sheep, young of all big game with horns less than 4 inches in length; grouse (except sharp-tailed grouse north of Red Deer River), partridges, prairie chickens, ptarmigan; pheasants, doves, swans, wood duck, rail, bitterns, little brown, sand-hill, and whooping cranes, grebes, gulls, herons, jaegers, loons, terns, and all shore birds (except Wilson's snipe or jacksnipe).

Hunting licenses: Nonresident: General, \$50; bird, \$5. Resident: Big game, \$1; bird, \$2.25, not required of farmer or member of family residing with him on farm nor of residents residing north of fifty-fifth parallel; guide, \$2.50 (guide may not act for more than three persons on any trip). Special license: Nonresident, \$50; resident, \$5 (issued to holders of general licenses and authorizes taking of deer, moose, and caribou in Rocky Mountain Forest Reserve of Alberta, north of North Saskatchewan River, Sept. 1 to Oct. 31, inclusive). Taxidermist, \$5. Issued by minister of agriculture. Consent of owner or occupant required for hunting on inclosed lands of another.

Bag limits and possession: Deer, moose, caribou, mountain sheep, mountain goat, bear, 1 of each species a season; sharp-tailed grouse, 5 a day, 25 a season; Hungarian partridges, 15 a day, 75 a season; 30 ducks a day, 200 a season; 15 geese, 25 coots, 25 Wilson's snipe, a day. Migratory game birds legally taken during the open season may be possessed until Mar. 31.

Export: Export of all protected game prohibited, except that minister of agriculture may grant permits for export of game at rate of \$5 for each head of big game and \$1 a dozen for game birds. The holder of a general nonresident license may take with him out of Province as trophies, heads, skins, and hoofs of big game legally killed by him. Any person may export mounted or branded heads at a fee of \$1 a head. Export of migratory birds prohibited during close season.

Sale: Sale of migratory game birds and flesh of all other game prohibited. Heads of big game before being sold must be stamped by minister of agriculture at fee of \$5 for elk, caribou, moose, mountain sheep, and \$2 each for deer and mountain goat.

BRITISH COLUMBIA

Open seasons: ⁶	Dates inclusive
Bull moose, in Atlin, Fort George, Cariboo, and Omineca electoral districts and Kamloops electoral district north of fifty-first parallel.....	Sept. 1-Dec. 15.
In Columbia electoral district.....	Sept. 15-Oct. 31.
Bull caribou, in eastern district except in Mackenzie and Skeena electoral districts, Cariboo electoral district west of Fraser River, and except south of main line Canadian Pacific Railway.....	Sept. 1-Dec. 15.
Bull elk (wapiti) in Fernie and Columbia electoral districts (except west of Columbia River).....	Sept. 15-Oct. 15.
Male mountain sheep, in eastern district north of Canadian National Railway and in Cariboo and Lillooet electoral districts south of the main Chilcotin River, and west of Fraser River, and in Fernie, Cranbrook, and Columbia electoral districts.....	Sept. 1-Nov. 15.
Mountain goat in eastern district (except North and South Okanagan, and Grand Forks-Greenwood electoral districts).....	Sept. 1-Dec. 15.

⁴ See footnote on p. 37, col. 1.

⁶ *British Columbia:* Regulations prescribing seasons, bag limits, and restrictions on sale of upland game birds for season 1930-31 are adopted by lieutenant governor in council. Full information may be had from provincial game commissioner, Vancouver.

Open seasons—Continued.

Mountain goat—Continued.	<i>Dates inclusive</i>
In western district (except Vancouver Island).....	Sept. 15-Dec. 15.
Male deer (mule, white-tail, coast) in eastern district (does, Nov. 15-Nov. 30) (see exception).....	Sept. 1-Nov. 30.
<i>Exception:</i> White-tailed deer in North and South Okanagan and Similkameen electoral districts and west of summit of Midway Mountains in Grand Forks-Greenwood electoral district.....	No open season.
In western district (see exceptions).....	Sept. 15-Dec. 15.
<i>Exceptions:</i> Bucks only, in North and South Saanich and Highland districts on Vancouver Island.....	Sept. 15-Oct. 31.
Deer on Queen Charlotte Islands and Hornby Island.....	No open season.
Bear (except white or Kermodei bear) in eastern district.....	Sept. 1-June 30.
In western district.....	Sept. 15-June 30.
Band-tailed pigeon, in western district only.....	Sept. 15-Oct. 15.
Duck, goose, brant, coot, Wilson's snipe or jacksnipe; Eastern district? (see exception).....	Sept. 15-Dec. 31.
<i>Exception:</i> In Creston electoral district.....	Sept. 15-Nov. 30.
Duck, goose, coot, Wilson's snipe or jacksnipe: Western district?.....	Oct. 15-Jan. 31.
Black brant: Western district?.....	Nov. 15-Feb. 28.
No open season: Buffalo; young of mountain goats; moose, caribou, elk, deer, except as above; and mountain sheep, except males over 1 year of age as above; rail, swans, wood duck, little brown and sand-hill cranes, anklets, auks, bitterns, fulmars, grebes, guillemots, gulls, herons, jaegers, loons, mures, petrels, puffins, shearwaters, terns, and all shore birds (except Wilson's snipe).	

Hunting and fishing licenses: Nonresident: General, \$25 and \$25 additional for each grizzly bear, moose, mountain sheep, wapiti, or caribou, \$15 additional for each black or brown bear, mountain goat, or mule deer, and \$5 additional for every deer of any other species shot by him; angling, season \$10; British subject, birds \$5 a week. Resident British subjects or farmers as defined under game act, and members of army, navy, air forces, or militia on duty in Province: Deer and birds, \$2.50; big game and birds, \$5. Big game, birds, and trapping, \$10 (holder must report within 2 months after expiration of license number of big game or fur animals taken); resident alien, \$10 (big game and game birds only); guide, \$5; taxidermist, \$5. Issued by warden or any person authorized by him.

No fee required of farmer holding more than 10 acres of land or members of family for license to hunt birds and deer during open season on land on which he resides. Free license granted to resident prospector under certain conditions upon production of free miner's certificate. No license issued to person under 18 without written consent of parent or guardian, and then to hunt with firearms only under supervision of licensed adult. Unlawful to hunt on cultivated, cleared, or inclosed land without owner's consent.

Badge to be worn by licensee. Firearms not to be carried without license.

⁷ *Western district* includes that portion of Province west of summit of Cascades and south of Atlin electoral district, except for migratory birds, south of southern boundaries of Skeena and Prince Rupert electoral districts, excluding that portion of Lillooet electoral district east of easterly railway yard limit of Alta Lake Railway Station on Pacific Great Eastern Railway. *Eastern district* includes rest of Province.

Bag limits and possession: One moose, 2 caribou (except in eastern district south Canadian National Railway, limit 1), 1 elk (wapiti), 2 mountain sheep (except in Fernie, Cranbrook, Columbia electoral districts, and in Cariboo and Lillooet electoral districts, south of main Chilcoot River and west of Fraser River, limit 1), 2 mountain goats, 2 deer in eastern district, 3 in western district, 2 grizzly bears, 3 bears of any other species a season; 10 band-tailed pigeons a day, 50 a season; 20 ducks a day, 150 a season; 10 geese a day, 50 a season; 10 brant a day, 50 a season; 25 Wilson's snipe a day, 150 a season; 25 coots a day, 150 a season. (Limits on other species of game fixed by regulations of lieutenant governor in council.) Game may be possessed for 2 weeks after close of open season. Unlawful for a dealer in skins to possess the skin of any wapiti (elk) or deer.

Export: Export prohibited of all game except under permit of provincial game warden.

Sale: Sale of migratory game birds prohibited and of all other game, except under regulations of lieutenant governor in council; provided, bull moose and bull caribou may be sold in Atlin and Omineca electoral districts from Sept. 1 to Dec. 15, and bears (except white or Kermodei bears) in eastern district from Sept. 1 to June 30, and in western district from Sept. 15 to June 30.

MANITOBA

Open seasons:	Dates inclusive
Deer, moose, caribou, or reindeer (males).....	Dec. 1-Dec. 10.
Ptarmigan.....	Oct. 1-Oct. 20.
Duck, goose, brant, coot, Wilson's snipe (see exception).....	Sept. 15-Nov. 30.
Exception: Duck, north fifty-third parallel.....	Sept. 1-Nov. 30.

No open season: Bison or buffalo, elk or wapiti, antelope or cabri, females and young of big game; quails, prairie chicken, partridges, ruffed grouse, quail, pheasants, Hungarian partridges, introduced game birds; rail, swans, wood duck, eider ducks, woodcock, bitterns, little brown, sand-hill, and whooping cranes, grebes, gulls, herons, jaegers, loons, terns, and all shore birds (except Wilson's snipe or jacksnipe).

Hunting licenses: Nonresident alien, big game, \$40; birds, \$25. Nonresident British, big game, \$25; birds, \$10. Resident, big game, \$5; birds, \$2. Issued by minister of mines and natural resources. License to hunt deer not issued after November 30. Hunting prohibited on inclosed or cultivated land or land covered by buildings or water, without consent of owner. No license required of farmers or members of family to hunt on farm of 40 acres or more on which they reside. Holder of resident bird license required, on or before December 15, to return license with sworn statement that he has not violated the act.

Bag limits and possession: One in all of deer, moose, and caribou a season; 15 ptarmigans a day, 50 a season; 15 ducks a day in September, 30 a day in October and November, 150 a season; 10 geese, 15 brant, 25 coots, and 25 Wilson's snipe a day. Possession of ptarmigans allowed for 10 days after close of hunting season and of migratory game birds until March 31. Venison for private use may be possessed at any time on proof of legal killing. Heads and hides of big game legally taken, within or without Province, may be possessed at any time.

Export: Export prohibited of all protected game, except under permit issued by department of mines and natural resources. No permit may be issued for export of ptarmigans, geese, ducks, or entire carcass of any moose, caribou, or deer; provided, nonresident licensee under permit issued free may export carcass of moose, caribou, or deer, and not more than 50 geese and 50 ducks killed by him. (No ducks may be exported before Oct. 1.) Export of migratory birds prohibited during close season.

Sale: Sale of all protected game prohibited except heads and hides of big game.

Miscellaneous: Big-game hunter must wear complete outer suit and cap of white material.

⁸ Manitoba: Open season may be shortened or closed or bag limits reduced by order-in-council.

NEW BRUNSWICK

Open seasons:	Dates inclusive
Deer (see exception).....	Sept. 15-Nov. 30.
Exception: On Grand Manan, Campobello, and Deer Island.....	No open season. ⁹
Bull moose (antlers must have 10 points).....	Oct. 1-Nov. 30.
Partridge (see exception).....	Oct. 1-Oct. 15.
Exception: On Grand Manan, Campobello, and Deer Island.....	No open season.
Duck, goose, brant, rail, coot, gallinule (see exception).....	Sept. 15-Dec. 31.
Exception: Islands in Grand Manan group.....	Oct. 15-Jan. 31.
Woodcock, jacksnipe or Wilson's snipe (see exception).....	Oct. 1-Nov. 30.
Exception: Islands in Grand Manan group.....	Oct. 15-Nov. 30.

No open season: Caribou (Oct. 1, 1940); calf moose under 3 years and cow moose; pheasants, swans, wood duck, auks, bitterns, fulmars, gannets, grebes, guillemots, gulls, herons, jaegers, loons, murrets, petrels, puffins, shearwaters, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident: Big game, \$50 (1 bull moose, 2 deer, 2 bears); \$25 (2 deer); special license, \$25 (2 bears, Apr. 1-June 30); bird, \$25; trout, season, \$10; salmon, season, \$25; special 3-day trout and salmon, \$5. Resident: Big game: \$3 (1 bull moose, 2 deer); \$2 (2 deer); bird, \$1; taxidermist, \$1; guide, \$1; camp help, \$1. Special license for salmon in reserved waters of the Restigouche: Nonresident, \$25 a day; resident, \$5 a day. Issued by minister of lands and mines and authorized vendors. Resident big-game licensees must report number of game animals killed thereunder not later than December 10, and return license and unused tags. Big-game license not issued to person under 18. Nonresident licensee must have registered guide, and not more than two hunters may accompany one guide.

Bag limits and possession: Two deer, 1 moose (lumber camp limited to 2 moose and 4 deer) a season; 6 partridges a day, 20 a season; 15 ducks a day, 150 a season; 15 geese, 15 brant, 25 in all of rails, coots, gallinules, and 25 Wilson's snipe a day; 8 woodcock a day, 125 a season. Game may be kept for personal use in cold storage during close season under permit, but migratory game birds may not be possessed after January 31.

Export: Export of all game prohibited, except game killed by nonresident licensee may be exported, within 15 days after being killed, under permit from Canadian customs office.

Sale: Sale of all game prohibited, except that a licensed hunter may sell moose or deer that he has lawfully killed. Keepers of hotels, inns, etc., may serve game during open season and 15 days thereafter. Hides and skins of animals may be sold under license by nonresidents or aliens, fee, \$25, and residents, fee, \$5.

NORTHWEST TERRITORIES¹⁰

Open seasons:	Dates inclusive.
Deer and moose* (males only), mountain goat.....	Sept. 1-Mar. 31
Mountain sheep, caribou.....	Sept. 1-Feb. 28.
Partridge, prairie chicken, ptarmigan, and other grouse.....	Sept. 1-Dec. 31.
Duck, goose, brant, rail, coot, gallinule, Wilson's snipe.....	Sept. 1-Dec. 14.

⁹ New Brunswick: Minister of lands and mines may issue license (fee, \$1) to resident of Grand Manan, Campobello, or Deer Island to take 1 deer, Oct. 15-Nov. 15.

¹⁰ "Northwest Territory means the northwest territories formerly known as Rupert's Land and the northwestern territory (except such portions thereof as are included in Provinces of Ontario, Quebec, Manitoba, Saskatchewan, and Alberta and Yukon Territory), together with all British territories and possessions in North America and all islands adjacent thereto not included within any Province, except Colony of Newfoundland and its dependencies."

No open season: Buffalo or bison; musk-oxen, wapiti or elk, does; females of moose, caribou, mountain sheep, and mountain goats with young, and young of any such animals; swans; auks, bitterns, little brown and sand-hill cranes, fulmars, grebes, guillemots, gulls, jaegers, loons, murrelets, terns, and all shore birds (except Wilson's snipe or jacksnipe). Arctic Islands Preserve, Peel River, Yellowknife, and Slave River preserves, reserved as exclusive hunting and trapping grounds for native Indians, Eskimos, and half-breeds. All hunting prohibited in Thelon Game Sanctuary.

Hunting and trapping licenses: Nonresident, \$150. Nonresident British subject: General, \$75; game birds, \$5. Resident, \$2. Trading or trafficking in game: Nonresident, \$300; nonresident British subject, \$150; resident, \$5. Issued by director of Northwest Territories. Permit from commissioner required to establish trading post. License, before leaving Territory, or as soon as practicable after expiration of license, must return license to nearest game officer or warden with a statement of number of each kind of game killed, or trafficked in. Native-born Indians, Eskimos, or half-breeds bona-fide residents of Northwest Territories may hunt without a license.

Bag limits and possession: Twenty-five ducks, 15 geese, 15 brant, 25 in all of rails, coots, and gallinules, and 25 Wilson's snipe a day. Migratory game birds legally taken during open season may be possessed until Apr. 14.

Export: Export of the meat or the raw skins of game animals prohibited, except under permit from minister or authorized officer.

Sale: Sale of migratory game birds during close season and of all other game illegally taken prohibited.

NOVA SCOTIA

Open seasons:	Dates inclusive
Bull moose (except on Cape Breton Island, no open season), male deer	Oct. 16-Nov. 15. ¹¹
Hare, rabbit	Nov. 1-Feb. 28.
Ruffed grouse	Oct. 16-Nov. 1.
Duck, goose, brant, rail, coot, gallinule (see exceptions)	Oct. 1-Jan. 15.
Exceptions: Goose, brant, in Halifax, Shelburne, and Queens Counties (only persons holding license from minister)	Dec. 1-Feb. 14.
Duck, rail, in Cumberland County	Sept. 15-Dec. 31.
Woodcock, Wilson's snipe or jacksnipe	Oct. 1-Nov. 30.

No open season: Caribou, does, cow moose, and young of deer and moose under 2 years of age; Canada grouse (spruce partridges) Hungarian partridges, pheasants; swans, wood duck, auks; bitterns, fulmars, gannets, grebes, guillemots, gulls, herons, jaegers, loons, murrelets, petrels, puffins, shearwaters, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting licenses: Nonresident or alien: All game, \$50; birds and small game, except woodcock and snipe, \$15. Resident: Big game, \$2, guide, \$2. Taxidermist, \$5. Issued by minister of lands and forests and agents. Licenses not issued to persons under 18.

Bag limits and possession: One deer, 1 moose, season; 5 ruffed grouse a day, 10 a season; 25 ducks, 15 geese, 15 brant, 25 in all of rails, coots, and gallinules, 25 Wilson's snipe a day; 8 woodcock a day, 125 a season. The green hide or fresh meat of moose and deer may be possessed Oct. 16 to Nov. 20, and migratory game birds legally taken during open season may be possessed for one month after close of open season, except geese may be possessed until the last day of February in Halifax, Queens, and Shelburne Counties.

Export: Export prohibited of all protected game except that holder of nonresident general license

may ship out of Province under license tag 1 moose lawfully shot by himself. Hares or rabbits lawfully killed may be exported at any time.

Sale: Sale of deer, moose, caribou, pheasants, black cock, capercaillie, Canada grouse (spruce partridge), chukar partridges, ruffed grouse, Hungarian partridges, and all migratory game birds prohibited. Rabbits may be sold Nov. 1 to Mar. 1.

ONTARIO

Open seasons: ¹²	Dates inclusive
Deer, bull moose, north of main line Canadian National Railway, between Quebec and Manitoba boundary lines	Sept. 15-Nov. 25.
South of Canadian National Railway to Mattawa River and Canadian Pacific Railway to Heron Bay, north shore Lake Superior	Oct. 20-Nov. 25.
South Canadian Pacific and Heron Bay and north Lake Nipissing and French River (see exception)	Nov. 1-Nov. 25.
Exception: On St. Joseph Island, Algoma district	Nov. 10-Nov. 25.
South of French and Mattawa Rivers (except in Carleton, Dundas, Glengarry, Grenville, Leeds, and Stormont Counties, and in Bruce, Grey, Simcoe, and York Counties, and territory south and west thereof no open season)	Nov. 5-Nov. 20.
Hare	No close season.
Woodcock	Sept. 15-Nov. 30.
Duck, goose, brant, Wilson's snipe or jacksnipe, rail, coot, gallinule	
North and west of French and Mattawa Rivers and in all Georgian Bay waters (see exception)	Sept. 1-Dec. 15. ¹³
Exception: Eider duck, north of Quebec, Cochrane, Winnipeg line of Canadian National Railway, only	Sept. 1-Dec. 15.
South of French and Mattawa Rivers, but not including Georgian Bay waters	Sept. 15-Dec. 15. ¹³

No open season: Caribou, cow and calf moose and moose under 1 year of age; black or gray squirrels, quail, ruffed grouse or partridges, pheasants or prairie fowl, wild turkeys; doves, swans, wood duck,¹³ eider duck (except as above), auks, bitterns; little brown, sand-hill, and whooping cranes; gannets, grebes, guillemots, gulls, herons, jaegers, loons, murrelets, petrels, terns, and all shore birds (except woodcock and Wilson's snipe).

Hunting and fishing licenses: Nonresident: Game, \$41; game birds and rabbits, \$21; angling, \$5.50; special, \$10.50 (weekly license, for Lake Nipigon, Frazier Creek, and Nipigon River, north and west of Lake Helen); not required of children under 12 when accompanied by licensed nonresident, but catch is included in daily limit of such licensee. Resident, moose, \$6; deer, \$4; camp license, \$4 (allows 1 deer to 6 residents for food in camp); game, \$2 (required only in Brant, Elgin, Essex, Haldimand, Halton, Kent, Lambton, Lincoln, Middlesex, Norfolk, Oxford, Peel, Perth, South Huron, South Wellington, Waterloo, Welland, Wentworth, and York Counties); angling, 50 cents; (daily license, Eugenia Game Preserve), special, \$5.50 (good for 2 weeks in Lake Nipigon, Frazier Creek, and Nipigon River north and west of Lake Helen). Guide, \$2. Issued by department of game and fisheries.

Bag limits and possession: One deer, 1 bull moose, a season; 15 ducks a day, 150 a season; 15

¹¹ Nova Scotia: Every person killing a deer or moose must, within 10 days, make a written and signed report to minister showing his address, when and where such animal was killed, and its sex.

¹² Ontario: Lieutenant governor in council may alter current close season on any game animal or bird diminished in numbers.

¹³ Lieutenant governor in council may permit the taking of wood ducks under special regulations.

geese, 15 brant, 25 in all of rails, coots, and gallinules, and 25 Wilson's snipe a day. Eight woodcock a day; two or more persons hunting together under license may kill an average of 1 deer each. Possession of all game legally taken permitted during open season and until Mar. 31.

Export: Export of all wild game animals and birds prohibited; provided, 1 deer, 100 ducks, 1 bull moose, and under export permit bears or bear pelts, may be exported under nonresident hunting license if shipping coupon and, if required, affidavit of lawful killing be attached and contents of packages be open to view. Minister may issue permit for export of game, dead or alive at any time, except migratory birds during close season.

Sale: Sale or purchase of deer, moose, migratory game birds, quail, grouse, introduced pheasants, and Hungarian partridges prohibited.

PRINCE EDWARD ISLAND

Open seasons:	Dates inclusive
Hare, rabbit.....	Nov. 1-Feb. 1.
Partridge (open in odd, closed in even years).....	Oct. 15-Nov. 15.
Duck, goose, brant, rail, coot, gallinule.....	Sept. 15-Dec. 31.
Woodcock, jacksnipe or Wilson's snipe.....	Sept. 15-Nov. 30.

No open season: Pheasants, swans, wood duck, bitterns, little brown cranes, gannets, grebes, guillemots, gulls, herons, jaegers, loons, murrelets, petrels, shearwaters, terns, and all shore birds (except woodcock and Wilson's snipe or jacksnipe).

Hunting and fishing licenses: Nonresident: Game: Fee, \$5; sons, brothers, and sisters of residents returning for visit, \$2.50; guest permit fee, \$2.25 per week. Issued by game inspector or justice of peace. Hunting on inclosed lands without permission of owner prohibited. Nonresident, angling fee, \$2 (not required of son, daughter, sister, or brother of a permanent resident of Province). Issued by Provincial treasurer or game inspector.

Bag limits and possession: Three partridges a day; 25 ducks, 15 geese, 15 brant, 25 in all of rails, coots, and gallinules, and 25 Wilson's snipe a day; 8 woodcock a day, 125 a season. Migratory game birds legally taken in open season may be possessed until January 31.

Export: Export prohibited of all game, provided, nonresident licensee may carry out of Province 12 birds killed by himself if tagged and carried open to view. Export of migratory birds prohibited during close season.

Sale: Game lawfully killed (except migratory birds) may be sold during open season.

QUEBEC

Open seasons:	Dates inclusive
Bull moose (see exception).....	Sept 10-Dec. 31.
Exception: South of St. Lawrence River.....	Sept. 20-Dec. 31.
Deer.....	Sept. 1-Nov. 30.
Hare.....	Oct. 15-Jan. 31.
Bear.....	Aug. 20-June 30.
Birch or spruce partridge.....	Sept. 1-Dec. 15.
White partridge or ptarmigan.....	Nov. 1-Jan. 31.
Duck, goose, brant, rail, coot, gallinule, woodcock, jacksnipe or Wilson's snipe.....	Sept. 1-Dec. 15.

No open season: Caribou, cow moose, young of deer and moose, swans, wood duck, elder ducks, auks, bitterns, fulmars, gannets, grebes, guillemots, gulls, herons, jaegers, loons, murrelets, puffins, shearwaters, terns, and all shore birds (except woodcock and Wilson's snipe).

Hunting licenses: Nonresident: General, \$25 (members of incorporated hunting clubs, \$10). Resident, not British subject, \$5, resident, deer, \$1, moose, \$1. Resident British subject not hunting for own use must obtain special license. Issued by minister of colonization.

Bag limits and possession: Two deer, 1 moose, a season; 25 ducks, 15 geese, 15 brant, 25 in all of rails, coots, and gallinules, and 25 Wilson's snipe a day; 8 woodcock a day, 125 a season. Migratory

game birds legally taken during open season may be possessed until Mar. 31, and others during first 15 days of close season.

Export: Export of moose and deer, or parts thereof, prohibited, except nonresident licensee may take out game animals killed by himself, under customs declaration and approval of Canadian collector of customs; export of grouse or partridges and of migratory birds prohibited during close season. Big game lawfully taken and coming from without Province may be transported under permit issued by minister of colonization.

Sale: Sale of deer and moose or any part thereof, and of all migratory game birds (except ducks during the open season) prohibited; also spruce partridges until October 15, 1935. Other game lawfully taken may be sold from the third day of open season to and including the fifteenth day after expiration of open season. Licensed hotels, restaurants, and clubs may serve meat of hares, bears, ducks, and ptarmigan lawfully taken.

SASKATCHEWAN

Open seasons: ¹⁴	Dates inclusive
Deer, moose (males only), caribou (see exception).....	Nov. 15-Dec. 14.
Exception: South of Township 35.....	No open season.
Hungarian partridge.....	Oct. 1-Oct. 31.
Duck, goose, coot, Wilson's snipe, or jacksnipe.....	Sept. 15-Dec. 31.

No open season: Antelope, buffalo, elk, and females of big game other than caribou, and young of big game under 1 year of age.¹⁵ Sage grouse, prairie chickens, pinnated grouse, sharp-tailed grouse, ruffed grouse, partridges, Canada grouse, spruce grouse, ptarmigan, rail, swans, wood duck, bitterns, little brown, sand-hill, and whooping cranes, grebes, gulls, herons, loons, terns, and all shore birds (except Wilson's snipe or jacksnipe).

Hunting licenses: Nonresident alien: Big game, \$50; birds, \$25; nonresident domiciled in Canada: Big game, \$25; birds, \$10; issued by minister of railways, labor, and industries. Resident: Big game, \$5; birds, \$1.50; issued by minister or agent. Bird license not required of residents hunting on land outside city, town, village, or hamlet on which they are actually domiciled. No license issued to person under 16 without written consent of parent or guardian. Big-game hunters must wear white suit and cap. Hunting prohibited on inclosed lands without consent. Taxidermist, \$5.

Bag limits, and possession: One moose, 1 deer, 1 caribou, but not more than 1 big-game animal a season; 10 Hungarian partridges a day, 30 a season; 30 in all of waterfowl, but not more than 10 geese, a day; 150 in all of waterfowl, but not more than 20 geese, a season; 25 coots a day, 150 a season; 15 Wilson's snipe a day, 150 a season. Game birds may be kept in licensed storage from Sept. 16 to Mar. 1, and flesh of big game from Dec. 1 to Apr. 1, if tagged with number and kind of game, name of depositor, and number of his hunting license. Licensed hunters must report number of big game and game birds killed.

Export: Export of all protected game prohibited; provided, nonresident licensee on leaving Province may take with him during open season personally under his license coupons and permit big game and 100 game birds legally killed. Export of migratory birds prohibited during close season. Minister may issue permits to export deer (fee, \$2 a head) or other big game (fee, \$5 a head), hides of big game (fee, \$1 each), flesh of big game (fee, \$1 each 20 pounds or less); birds (fee, \$1 a dozen; limits, 5 dozen waterfowl a season). No permit may be issued for the entire carcass of a moose, caribou, or other deer, and no person may export in one season more than 60 ducks or geese.

Sale: Sale of migratory game birds and flesh of all other protected game prohibited.

¹⁴ Saskatchewan: Lieutenant governor in council may extend close seasons over current year, within limits, on petition of six game guardians.

¹⁵ Male moose having horns less than 6 inches in length deemed to be under 1 year of age.

YUKON

Open seasons:¹⁶

Dates inclusive

Deer, moose, caribou, mountain sheep, mountain goat (males only).....	Aug. 1-Mar. 1.
Partridge, prairie chicken, grouse, ptarmigan, pheasant.....	Sept. 1-Mar. 15.
Duck, goose, brant, rail, coot, gallinule, Wilson's snipe or jacksnipe.....	Sept. 1-Dec. 14.

No open season: Moose or caribou under 1 year of age; elk or wapiti, musk-oxen, bison or buffalo, and females of other big game; swans, cranes, grebes, gulls, jaegers, loons, terns, and all shore birds (except Wilson's snipe or jacksnipe).

Hunting licenses: Nonresident, \$100 (permits the killing of 1 moose, 2 deer, 2 caribou, 1 mountain sheep, and 1 mountain goat); licensee in addition may kill 1 moose, 2 deer, 2 caribou, 1 mountain sheep, and 1 mountain goat, but must pay a fee of \$25 for each additional animal so taken. Resident, \$25 (special license authorizing the killing of male moose and male caribou over 1 year of age at any time for food supplies in the Territory);

¹⁶ Yukon: Indians, explorers, surveyors, prospectors, miners, and travelers in need of food may take game during close season. Commissioner in council may alter seasons.

licensee must make annual returns. Resident: Chief guide, \$20; assistant guide, \$10. Issued by commissioner or game guardian.

Bag limits and possession: (For limits on big game to a nonresident, see "Hunting licenses.") Six caribou, 6 deer, 2 moose, 2 mountain sheep, 2 mountain goats, 6 bears a season; 25 ducks, 15 geese, 15 brant, 25 in all of rails, coots, and gallinules, and 25 Wilson's snipe a day. Migratory game birds legally taken during open season may be possessed until Apr. 14.

Export: Export of migratory birds prohibited during close season. Upon affidavit of lawful killing, commissioner may issue permit to export game. Export of raw hide of moose or caribou prohibited except under permit. Trophies, including head, hide, and hoofs, of big game lawfully killed by nonresident may be exported under his license and certificate of game guardian.

Sale: Deer, moose, caribou, mountain sheep, and mountain goats lawfully taken may be sold during the open season and 60 days thereafter. Male moose and male caribou more than 1 year of age killed by a resident under special license may be sold at any time for food upon obtaining certificate of lawful killing from a game guardian. License (fee, \$10) required to purchase and traffic in flesh of moose or caribou. Licensee must make annual returns. Sale of migratory birds prohibited during close season.

NEWFOUNDLAND

Open seasons:

Dates inclusive

Hare, rabbit.....	Oct. 1-Dec. 20. ¹⁷
Ptarmigan, willow grouse or partridge, goose, plover, curlew, snipe, or "other wild or migratory birds (except crows and hawks, unprotected)".....	Oct. 1-Dec. 20. ¹⁷

No open season: Elk, moose, caribou, capercaillie or black game.

¹⁷ Newfoundland: Hare or rabbit may also be taken with trap or snare until Mar. 1. Unlawful to possess hares or rabbits, ptarmigan or grouse in storage, Oct. 1 to Oct. 10.

Fishing licenses: Nonresident: Fish (salmon and sea trout), season, \$26; 14-day license, \$10.50; 4 days or less, \$2.10 a day. Guide, nonresident, \$50; resident free. Issued by game and inland fisheries board.

Unlicensed guides not to be employed. Guide may not conduct party of more than three.

Export: Export or canning of ptarmigan and other game birds prohibited.

Sale: Ptarmigan and willow grouse may be sold Oct. 10-Jan. 1; other birds may be sold during open season; rabbits, Oct. 10-Mar. 15.

MEXICO

Open seasons:¹⁸

Dates inclusive

Upland plover.....	Sept. 1-Sept. 30.
Wilson's snipe or jacksnipe, duck, goose, swan.....	Nov. 1-Feb. 28.
Other shorebirds.....	Aug. 16-Sept. 30.
White-winged dove.....	Sept. 16-Nov. 30.
Pigeons and other doves.....	Oct. 1-Dec. 31.
Wild turkey, curassow, cojote.....	Sept. 1-Dec. 31.
Rabbit.....	Sept. 1-Feb. 28.
Deer, male, northern region, central tablelands (and similar places more than 1,000 meters above sea level).....	Oct. 16-Jan. 31.
Deer, male, northwest region (Lower California, Sonora, and Sinaloa).....	Sept. 16-Dec. 31.
Deer, male, south of Tropic of Cancer.....	July 1-Sept. 30.
Bear.....	Sept. 1-Oct. 31.
Peccary.....	Aug. 1-Feb. 28.

¹⁸ Mexico: Secretaria de Agricultura y Fomento, City of Mexico, has authority to establish seasons and issue licenses.

Open seasons—Continued.

Dates inclusive

Alligator.....	Sept. 16-May 31.
Anteater, kinkajou.....	Oct. 1-Jan. 31.
Paca, armadillo.....	Nov. 1-Jan. 31.
Tapir.....	Sept. 1-Nov. 30.

No open season: Antelope, mountain sheep (1932). White heron (1931). Mule deer on Cedros Island (1933). Gulls, insectivorous and song birds, manatees, and the young and females of all animals.

Licenses:¹⁸ Hunting for sport: Nonresident alien: Municipality (10 days), \$3.30; 30 days, \$8.80. State (30 days), \$11; 60 days, \$16.50. Country (6 months), \$22; 1 year, \$44. Resident citizen or resident alien: Municipality (10 days), \$1.10; 1 year, \$5.50; State (6 months), \$5.50, 1 year, \$11; Country, (6 months), \$11; 1 year, \$22. Licenses and permits also required for professional and commercial hunting and for the utilization of game products.

Export: Export of live game birds or animals prohibited except under special permit to a limited number of concessionaires. Fees vary for different species.

IMPORTED GAME AND GAME RAISED IN CAPTIVITY

The Department of Agriculture, acting in conjunction with State game officials and sportsmen, aids so far as possible in establishing the game-breeding industry by preparing drafts of suitable laws to be enacted by the States, issuing permits to breeders to obtain wild migratory waterfowl and their eggs, and otherwise advising where stock may be obtained. The department does not distribute breeding stock or eggs, but in proper cases and under suitable restrictions issues permits to assist legitimate enterprises in the conduct of the business of game farming. The possession, sale, and transportation of imported game and game raised in captivity are also regulated in most States by State laws, which are covered in the following summary:

Federal regulations:¹⁰ Under permit from the Secretary of Agriculture, and subject to the provisions of State laws, live migratory waterfowl raised in captivity may be possessed, sold, and transported at any time for propagation, and such birds may be killed in any manner (except that they may be killed by shooting only during the open season for waterfowl in the State where killed) and carcasses with heads and feet attached may be sold and transported at any time to any person for actual consumption, or to the keeper of a hotel, restaurant, or boarding house, retail dealer in meat or game, or a club, for sale or service to their patrons who may possess such carcasses for actual consumption without a Federal permit; provided that no migratory waterfowl killed by shooting shall be bought or sold unless each bird before attaining the age of 4 weeks shall have had removed from the web of one foot a portion thereof in the form of a V for identification purposes.

Permits also are issued under proper restrictions and subject to State laws for capturing a reasonable number of wild migratory waterfowl and taking their eggs to enable persons desiring to engage in the business to acquire the nucleus of a breeding stock or to improve the strain of birds on hand but such wild birds may be sold and possessed only for propagation and may not be killed or sold for food.

Alabama: Commissioner of game and fisheries may issue a permit (fee, \$1) to capture or export not more than 10 pairs of each species of game or birds for propagating purposes and to sell live game birds or their eggs, raised under permit.

Alaska: Under permit from Secretary of Agriculture wild animals, ducks, geese, and nonmigratory birds may be taken, possessed, bought, sold, and transported for propagation.

Arizona: State game warden may issue permit to take, export, or import game or birds for propagating purposes.

Arkansas: Permit (fee, \$2) required to propagate game in captivity.

California: Game raised in captivity under breeder's license (fee, \$2.50) may be sold for breeding purposes, and under regulations of commission may be sold for food if tagged (fee, 3 cents a tag). All game raised in captivity (except deer) must be killed otherwise than by shooting. Permits may also be issued to capture, possess, or transport wild game animals and game birds for propagating purposes. Shipments by parcel post are prohibited. Pheasants and domesticated reindeer may be imported and sold under regulations of commission.

Colorado: Game raised in licensed private parks, if accompanied by an invoice, and game (except migratory birds other than migratory waterfowl raised in captivity in conformity with Federal regulation—No. 8) brought into State by licensed importer, if shipping invoice is indorsed to purchaser, may be sold and transported. Commissioner may issue permit to capture or import game for propagating purposes.

Connecticut: Game birds and quadrupeds raised in preserve under license (fee, \$2) may be sold and transported, if tagged, under regulations of commissioners of fisheries and game. Game

legally taken and transported from another State or country that does not prohibit its sale or export may be sold under regulations of the board. Permit required to import game protected in the State.

Delaware: Pheasants and Hungarian partridges may be possessed and sold for propagating purposes. Board, by permit (fee, \$1), may authorize any person to capture, possess, and transport not more than 10 pairs of each species of game or birds for propagating purposes.

District of Columbia: Hungarian partridges, English, Mongolian, Chinese, and ring-necked pheasants, and migratory waterfowl raised in captivity, in conformity with Federal regulations, may be possessed, sold, and transported.

Florida: Game-farming license (fee, \$5) must be obtained from State game commissioner. Game and birds may be taken for propagation under permit of commissioner and game raised on licensed preserve or farm may be sold for propagation and food purposes.

Georgia: Registered breeder may possess, buy, sell, and transport game for propagation.

Idaho: Permit of State game warden required to take or keep waterfowl in captivity for decoy purposes. Under regulations of the State game warden, game may be propagated in private parks.

Illinois: Game raised in captivity under a breeder's license (fee, \$5) may be possessed, sold, and transported for propagating purposes and, under special permit, may be killed, transported, and sold for food.

Indiana: Birds and animals raised in captivity may be kept, killed, sold, or transported under certificate of inspection (fee, \$5) from the conservation commission, and game birds legally acquired may be possessed for breeding purposes under like certificates.

Iowa: Game birds raised in captivity under license (fee, \$2) may be sold for food or propagating purposes.

Kansas: Game raised in captivity under permit (fee, \$2) may be sold and transported, and, under permit and regulations of warden, wild animals and birds and eggs of birds may be taken for propagating purposes.

Kentucky: Game birds and game animals raised in captivity under permit may be sold and transported, but all carcasses must be tagged.

Louisiana: Game raised in captivity under license (fee, \$10) may be sold and transported for food, stocking, or breeding purposes, but all carcasses must be tagged. Traffic prohibited in birds killed by shooting. Licensed game breeder may, under permit, take wild animals or birds for breeding stock, but not for killing. Wild birds or mammals may be brought into State for liberation, and game may be exported for educational, scientific, or propagating purposes, under permit from commissioner.

Maine: Game raised in captivity under breeder's license (fee, \$2) may be killed, sold, and transported under regulations of commissioner, and live game may be captured or exported for breeding and advertising purposes, under regulations and permit of commissioner.

Maryland: Game raised in captivity under breeder's license (fee, \$5) may be sold and transported under permit and tag of State warden. Such game must be offered to State warden before being

¹⁰ See Federal regulation 8 for full details and requirements (footnote 1, p. 5).

offered for sale elsewhere. Chinese, English, Mongolian, or ring-necked pheasants raised in captivity may be killed by shooting or otherwise from November 10 to December 31 on premises where raised.

Massachusetts: Under regulations of division of fisheries and game, deer, elk, pheasants, quail, and European or gray partridges raised in captivity under license (no fee), may be sold for propagation, and killed and sold for food purposes, if tagged; and licensed dealers may sell unplucked bodies of pheasants, Scotch grouse, European black game, European or gray partridges, red-legged partridges, and Egyptian or migratory quail imported from without the United States, if tagged, and deer, moose, caribou, and elk lawfully killed and coming from without State, if tagged by warden of State or country where procured. State tag fees, 5 cents each. Hares and rabbits may be sold during the open season if secured and imported from a country where their sale is not prohibited. Waterfowl may be reared in captivity and sold under Federal regulations (No. 8).¹⁰

Michigan: Game animals or birds raised in captivity under license (fee, \$5 to \$50) may be sold and transported for food, breeding, or stocking purposes. Carcasses of such game must be tagged (tags, 5 cents each). Licensed dealer, club, hotel, restaurant, or boarding house (fee, \$5) may sell or serve imported game or game raised in captivity, if tagged, to patron or customer for actual consumption or use.

Minnesota: Game (except deer and Hungarian partridges) raised in captivity under license (fee, \$3, and 15 cents additional for each acre over 10 acres) may be sold alive for propagating purposes, and may be killed, sold, and transported under regulations of commissioner. Under regulations of the commissioner, wild animals and birds and eggs of birds may be taken for propagation.

Mississippi: Licensed owner or operator of game preserve may buy, sell, or transport within or out of the State for propagating purposes game raised on such preserve, but no game may be shipped out of State except during open season thereon.

Missouri: Deer, elk, and other protected game raised in captivity under license (fee, \$5) may be transported and sold under regulations of commissioner. Export (except of quail) for propagating purposes allowed under permit.

Montana: Game raised in private preserves under license (fee, \$5) may be killed, sold, and transported. Commission may authorize capture under permit of wild animals and birds for propagation.

Nebraska: Game animals and birds may be raised in captivity for profit under license (fee, \$1 to \$10, according to number of birds or animals, 25 to 50 or more, and regulations of commission, or for nonprofit purposes, fee, \$1) may be sold for propagation, and killed and sold for food purposes if tagged. Keeper of hotel, boarding house, restaurant, club, or retail dealer in meats under license (fee, \$5) may sell tagged game to patron or customer for actual consumption, but tags must remain on carcasses until consumed.

Nevada: Game raised under license (fee, \$25) may be sold or shipped under invoice.

New Hampshire: Game raised in captivity under license (fee, \$2) may be sold and transported, if tagged, under regulations of commissioner. Game (except ruffed grouse) imported from without the United States or raised in private preserves, if tagged and marked to show kind and number, name and address of consignor and consignee, initial point of billing, and destination, may be exported unaccompanied by owner.

New Jersey: Mallard, wood, and black ducks, Canada geese,¹⁰ English and Mongolian pheasants, quail, ruffed grouse, deer, rabbits, raccoons, and squirrels raised in preserves under license (fee, \$5) may be possessed and sold for propagation, and may be sold for food or exported for sale if tagged (tag fee, 5 cents). Unplucked carcasses of Scotch grouse, European black grouse, European black plover, red-legged partridges,

and Egyptian quail coming from a foreign country, if tagged by State authorities, may be sold for food purposes.

New Mexico: Game may be raised in licensed preserve. State warden may issue permit (fee, \$1.25) to retain in captivity not more than 4 abandoned young of big game that applicant has rescued. Holder of a hunting license, under permit from State warden, may capture and export game or birds for propagating purposes. Game (except migratory birds other than waterfowl raised in captivity in conformity with Federal regulations¹⁰) coming from without State may be possessed and sold by a hotel, restaurant, café, boarding house, or dealer under a permit good for not more than 30 days.

New York: Elk, mule deer, white-tailed deer, European red deer, fallow deer, Japanese deer, roebuck, pheasants, bobwhite, quail, Hungarian or gray-legged partridges, Canada and Hutchins's geese, and mallard and black ducks raised in captivity under license (fee, \$5) may be sold for breeding purposes; carcasses of quail or Hungarian or gray-legged partridges, raised in State, may not be sold for food nor may those killed by shooting be bought, sold, or trafficked in, but all other species mentioned may be killed, shipped, and sold or exported for food, if tagged. Such ducks and geese may be killed by shooting during the open season, but when so killed may not be sold unless marked and tagged as required by conservation department.¹⁰ Varying hares and cottontail rabbits raised in captivity under license (fee, \$5) if tagged, may be sold for food purposes during close season, under regulations of department.

Licensed breeders in States having laws similar to the game-breeding law of New York may, under license (fee, \$5) and cost of inspection, ship into State domesticated American elk, white-tailed deer, European red deer, fallow deer, roebuck, pheasants, Canada and Hutchins's geese, and mallard and black ducks, which, if tagged, may be sold under regulations of department.

License to possess and sell birds and quadrupeds for propagation, scientific, educational, or exhibition purposes, fee, \$1.

Unplucked carcasses of tinamou, pheasants, Scotch grouse, European gray-legged partridges, Norwegian ptarmigan, Norwegian grouse, and Egyptian quail, and species or subspecies not native to State, and carcasses of European red deer, fallow deer, and roebuck imported from without the United States may be sold under license if tagged. No restrictions on reindeer.

North Carolina: Game may be raised in domestication under regulations of department of conservation and development, and may be taken for propagation under permit (fee, \$1).

North Dakota: Game may be kept in captivity under permit of board.

Ohio: Ring-necked, Mongolian, or Chinese pheasants and mallard and black ducks raised in captivity under a breeder's license (fee, \$5) may be sold and transported for food or propagating purposes; carcasses of such birds must be tagged. No pheasant, mallard, or black duck raised in captivity may be killed by shooting except during the open season, and no mallard or black duck killed by shooting may be bought or sold unless it shall have had a well-defined V-shaped section removed from the web of one foot before attaining the age of four weeks.

Deer, squirrels, and rabbits legally taken or acquired may be possessed in inclosures as pets.

Oklahoma: Game raised under license (fee, \$2) may be sold and transported for propagation and for food, if tagged, during season prescribed by commission. Wild animals or birds may not be taken in State for breeding purposes.

Oregon: Game birds and animals raised in captivity under permit (fee, \$2) may be exported or sold for propagating, restocking, or food purposes; carcasses must be tagged (fee, 5 cents). Written permit from State warden, showing kind of game and names and addresses of consignor and consignee, must be attached to each shipment.

¹⁰ See Federal regulation 8 for full details and requirements (footnote 1, p. 5).

¹⁰ See Federal regulation 8 for full details and requirements (footnote 1, p. 5).

Game animals and birds coming from without the United States and game taken in a State where it may be sold, may be sold and transported under permit and tag of State warden, but the only migratory birds that may be sold are waterfowl reared in captivity under Federal¹⁹ or Canadian regulations.

Pennsylvania: Game breeder's certificate required, fee, \$1; bond, \$500. Game raised in captivity may be sold or transported within State; or, under permit, out of State but before live game raised under permit is shipped out of State it must be offered for sale to commission.

Rhode Island: Game raised in captivity under permit may be sold for propagation, under regulations of commissioners. Game lawfully killed and exported may be brought into State under permit, but such game may not be sold.

South Carolina: Game birds may be raised in captivity, and sold and shipped, under license (fee, \$2.50).

South Dakota: Game raised in captivity under license may be exported or sold under written permission of State game warden.

Tennessee: Under permit (fee, \$1) of State warden 10 pairs of game animals or birds may be taken for propagation. Special law in Rutherford County.

Texas: Game animals and birds may be captured or imported for propagating purposes under permit of commissioner.

Utah: Game raised in private preserve under permit (no fee) of commissioner may be sold and transported, if tagged.

Vermont: Game raised in licensed private preserve (fee, \$2) may be sold or exported for food or propagating purposes. Carcasses must be tagged.

Virginia: Game animals and birds raised under breeder's license (fee, \$25) may be disposed of for propagating or restocking, and, under regulations of commission, for other purposes.

Game breeder's license issued only to residents of State. Breeding stock may be acquired as determined by commission.

Washington: Game animals and birds raised in captivity under license (fee, \$20; renewal, \$10 annually) may be sold and transported at any time, or sold for food, if tagged. Keeper of hotel, restaurant, boarding house, or club, and retail dealer in meats may sell game raised under game farmer's license, if tagged. Under permit from supervisor of game and game fish wild animals and birds may be imported from without State for propagating purposes.

Game animals and birds coming from without State, if reported within three days and tagged (fee, 25 cents a tag), may be possessed for tanning, mounting, manufacturing, or ornamental purposes and disposed of in usual course of trade, but the only migratory birds that may be sold are waterfowl reared in domestication under Federal and Canadian regulations.¹⁹

West Virginia: The owner may kill elk or deer kept in inclosure and may pursue and recapture, by killing or otherwise, elk that have escaped from his inclosure. Game and fur animals, game birds, fish, and frogs may be taken under permit (fee, \$1) for propagation.

Wisconsin: Owner or lessee of lands within State may obtain license (fee, \$5; renewal, \$2) from conservation commission, and after inclosing property as required by law becomes owner of all game thereon and its increase. Such birds may be sold alive for propagation, or may be killed and sold for food when tagged (tag fee, 5 cents each), but no migratory waterfowl may be killed and sold except those actually bred in captivity under Federal permit.¹⁹ Commission may issue permits to park boards to take, possess, sell, and ship wild animals for park purposes, and to individuals to take for propagation under supervision of commission.

Wyoming: Under permit (fee, \$10) and supervision of commission, game animals may be taken

for propagation. Animals so taken may not be killed, sold, or disposed of for three years, but their natural increase may be sold, transported, and disposed of. Exchange of game animals and birds for liberation in State allowed under permit of State game commission.

Canadian regulations:²⁰ The Canadian regulations, administered by the commissioner of national parks of Canada, Ottawa, are similar to the provisions of the Federal regulations in respect to propagation of migratory waterfowl, but apply to all migratory birds protected by the treaty; and all birds raised in captivity and intended for food purposes must be killed otherwise than by shooting, and each of such birds before it can be sold must bear a metal tag, which may not be removed from carcass. Under section 5 of the Canadian customs export act (R. S. C., 1906, ch. 50) a person may export carcass or parts thereof of a deer raised on his own land or on lands owned by a company or association of which he is a member, upon his making affidavit on face of export entry that the carcass, or part thereof, is of a deer so raised.

Alberta: Minister of agriculture may authorize persons to possess, buy, sell, and export big game and game birds raised in captivity, and to capture big game and game birds for propagation. Permit fees fixed by lieutenant governor in council.

British Columbia: Game commissioner may authorize persons to possess, buy, sell, and export game animals and game birds raised in captivity, and to capture game animals and birds and collect eggs of birds for propagation. Permit required to import live animals or birds into the Province; permit fees fixed by lieutenant governor in council.

New Brunswick: Minister of lands and mines may authorize persons to possess, buy, sell, and export game raised in captivity, and to capture game for propagation. Permit fees fixed by minister.

Northwest Territories: Minister of the interior may authorize persons to possess, buy, sell, and export wild mammals and birds raised in captivity, and to capture wild mammals and birds and collect eggs of birds for propagation.

Nova Scotia: Minister may authorize persons to possess, buy, sell, and export wild mammals and birds raised in captivity, and to capture wild mammals and birds for propagation.

Ontario: Minister of game and fisheries may authorize persons to possess, buy, sell, and export game animals and birds raised in captivity, and to capture game animals and birds for propagation during close season. Imported game may be sold or exported under license.

Prince Edward Island: Domesticated wild geese and brant in captivity are deemed personal property of owner, and may be possessed, disposed of, and transported without reference to the provisions of the provincial game act. Waterfowl and other migratory birds, however, are subject to the provisions of the migratory birds convention act and regulations.²⁰

Quebec: Minister may authorize game animals and birds lawfully taken during the open season to be retained in captivity.

Saskatchewan: Minister of railways, labor, and industries may authorize persons to possess, buy, sell, and export big game and game birds raised in captivity, and to capture big game and game birds for propagation. All shipments must be tagged, Permit and tag fees fixed by minister.

Yukon: Gold commissioner may authorize persons to possess, buy, sell, and export game animals (except buffalo or bison) and birds raised in captivity, and to capture such animals and birds for propagation.

Newfoundland: Game and inland fisheries board may authorize persons to capture, possess, buy, sell, and export caribou for propagation. Eggs of wild geese may be taken until May 15 for propagation only.

¹⁹ See Federal regulation 8 for full details and requirements (footnote 1, p. 5).

²⁰ See Canadian regulation 13 (footnote 1, p. 5).

FIELD SERVICE, DIVISION OF GAME AND BIRD CONSERVATION BUREAU OF BIOLOGICAL SURVEY

[Violations of Federal game laws may be reported to the nearest official listed, or to the Chief, Bureau of Biological Survey, United States Department of Agriculture, Washington, D. C.]

UNITED STATES GAME PROTECTORS

Harry Barmeier	4947 Schollmeyer Avenue, St. Louis, Mo.
William L. Birsch	P. O. Box 177, New Bern, N. C.
Louis A. Branchaud	Biological Survey, Washington, D. C.
B. R. Britton	Box 185, Socorro, N. Mex.
M. A. Charlton	2106 Summit Street, Columbus, Ohio.
Frank Clarkson	Box 1168, Houston, Tex.
P. S. Farnham	Owego, N. Y.
William H. Hoffman	Box 1022, Mobile, Ala.
John Q. Holmes	Hotel Hill, Omaha, Nebr.
Floyd A. Johnson	1301 General Taylor Street, New Orleans, La.
Jay V. Kelsey	P. O. Box 1825, Daytona Beach, Fla.
Chester A. Leichhardt	516 Post Office Building, Portland, Oreg.
S. W. Linebaugh	Russellville, Ky.
Lawrence J. Merovka	43 Federal Building, Memphis, Tenn.
George E. Mushbach	Box 438, Billings, Mont.
John E. Perry	Sherman Hotel, Kansas City, Mo.
W. H. Ransom	Box 94, Spokane, Wash.
George M. Riddick	Box 815, Little Rock, Ark.
Kenneth F. Roahen	Box 306, Peoria, Ill.
B. J. Shaver	General Delivery, St. Paul, Minn.
Bertrand E. Smith	21 Rosemont Avenue, Portland, Me.
Albert Stadlmeir	45 Loraine Avenue, Pleasantville, N. J.
Orin D. Steele	125 Willis Street, Cambridge, Md.
George Tonkin	Box 393, Berkeley, Calif.
E. B. Whitehead	532 East Fifth Street, Savannah, Ga.

SUPERINTENDENTS OF FEDERAL WILD-LIFE REFUGES

Ray C. Steele	Upper Mississippi River Wild Life and Fish Refuge, Winona, Minn.
	Bear River Migratory-Bird Refuge, 337 State Capitol, Salt Lake City, Utah.

UNITED STATES RESERVATION PROTECTORS

George M. Benson	Lake Malheur Bird Reservation, Voltage, Oreg.
Steven B. Crossley	Big Lake Bird Reservation, Manila, Ark.
Fred M. Dille	Niobrara Reservation, Valentine, Nebr.
H. Harrison Hoyt	Wind Cave Game Preserve, Hot Springs, S. Dak.
Almer P. Nelson	Elk Refuge, Jackson, Wyo.
Wesley D. Parker	Sullys Hill Game Preserve, Fort Totten, N. Dak.
Frank H. Rose	National Bison Range, Moiese, Mont.

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The use of unsuitable or insufficient materials.

Improper laying of brick. Brick should not be laid on edge and should be properly bonded. Lack of mortar, especially in the perpendicular joints, ruins many an otherwise good chimney.

¹ Dwelling Houses, a publication issued by the National Board of Fire Underwriters in the interest of fire protection, has been used as a basis for the matter relating to the requirements and construction of chimneys and methods of fire protection.

FIELD SERV

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Harry Barmeier...
William L. Birsch
Louis A. Branchat
B. R. Britton.....
M. A. Charlton...
Frank Clarkson...
P. S. Farnham.....
William H. Hoffm
John Q. Holmes...
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Jay V. Kelsey.....
Chester A. Leichh
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Lawrence J. Mero
George E. Mushbo
John E. Perry.....
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Albert Stadlmair..
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E. B. Whitehead..

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CONSTRUCTION OF CHIMNEYS AND FIREPLACES

By the Division of Agricultural Engineering, Bureau of Public Roads

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INTRODUCTION¹

FIREPLACES AND CHIMNEYS should provide a safe passage to the open air for unburned and partially burned products of combustion; that is, smoke and sparks. If they are of improper design or construction, the result is poor performance and frequently excessive fuel consumption. Defective chimneys and flues are responsible for much of the annual farm fire loss. According to the National Board of Fire Underwriters, overheated or defective chimneys, flues, cupolas, and stacks were responsible for the destruction of \$26,343,759 worth of farm property during the five years 1924 to 1928, inclusive. The next greatest loss was that due to lighting and amounted to \$17,727,780.

CHIMNEYS

COMMON FAULTS IN CHIMNEY CONSTRUCTION

The most common faults in chimney construction are:

The use of unsuitable or insufficient materials.

Improper laying of brick. Brick should not be laid on edge and should be properly bonded. Lack of mortar, especially in the perpendicular joints, ruins many an otherwise good chimney.

¹ Dwelling Houses, a publication issued by the National Board of Fire Underwriters in the interest of fire protection, has been used as a basis for the matter relating to the requirements and construction of chimneys and methods of fire protection.

Failure to support the chimney properly. It should never be carried on any timber construction of the building, and when it rests upon the ground sufficient masonry foundation should be provided to prevent settling.

Building inflammable material into the chimney or against it without proper insulation.

Failure to anchor the smoke pipe properly to the chimney.

Neglect of the connection between smoke pipe and flue or of the flue itself. The connection should be tight; rusted pipe should be replaced; the chimney should be kept clean and the joints in the brickwork properly pointed.

Lack of a tight flue. A flue free from leakage is unusual. Every flue should be tight enough to prevent escape of smoke when tested as described on page 11. A leaky flue is the most frequent cause of heating troubles, high fuel bills, and destructive fires.

Failure to maintain the full sectional area at the bend when a flue is offset.

Use of the main heating-apparatus flue for water-heater or other auxiliary equipment. Each heating unit should have a separate flue.

Improper installation of clean-out doors.

DRAFT

The draft depends entirely upon the chimney flue. The better the flue the more satisfactory and efficient will be the operation of the entire heating apparatus. The strength or intensity of the draft is dependent mainly upon the tightness, size, and height of the chimney. The most common error in chimney construction is failure to distinguish between the size of flue necessary for free passage of the volume of smoke from a given amount of fuel and that which with proper height will produce the required draft. A chimney may be high enough, yet have an area too small to carry properly the volume of smoke. On the other hand, the size may be sufficient but the chimney too low to produce a strong draft. Either fault or a combination of the two will result in unsatisfactory service.

Draft in a chimney flue is caused by the difference in weight between a volume of air on the outside and an equal volume of products of combustion from the fire on the inside. The higher the temperature of a given weight of air, the greater is its total volume and the lighter the weight of its unit volume. This produces a condition of unbalanced pressure at the base of the flue. The rising of the lighter gases within the chimney tends to equalize the pressure. So long as the fire burns this condition of unbalanced pressure persists, the result being draft.

This is the basic principle which governs chimney action and upon which the draft depends. The greater the difference between the temperature in the flue and that outside the greater the tendency toward equalization of pressure and hence the better the draft. In summer the draft of a chimney is not as good as in winter because the difference in temperature between the outside air and that of the gases in the flue is less.

SHAPES AND SIZES OF FLUES

The most efficient chimney is one built perfectly straight with a round or nearly round flue and a smooth interior surface. There is no advantage in reducing the sectional area toward the top. The cross section and height are determining factors. The transverse area must be sufficient to pass the volume of air required to burn the fuel properly, and the height must be great enough to insure against interference with the draft by adjoining buildings or projections of the same building and to produce a sufficiently strong draft.

Loss in draft strength is due to air leakage and friction of the gases against the sides of the chimney. A round flue (fig. 1) is the most desirable because it offers less resistance to the spirally ascending column of smoke and gases. The elliptical is second choice so far as the movement of the gases is concerned, but the difficulties that it presents in manufacture and construction eliminate this shape. A rectangular chimney either square or oblong is not effective over its full transverse area; for the rising column being approximately circular in section, does not fill the corners. However, square or oblong forms are far more common than the round, owing to the greater cost of round-flue construction.

Square flues are preferable to oblong so far as efficiency is concerned, but in the larger sizes of house flues the oblong shape is more generally used because it fits to better advantage into the plan of the house. An oblong flue should never have the

long side more than 4 inches greater than the short side. The sizes given in Table 1 are recommended by the National Warm Air Heating and Ventilating Association. Like all data for both high and low pressure flues, these sizes are based on experience, not on scientific data, and are subject to modification by further research. The dimensions given are for unlined flues. The actual inside dimensions of fire-clay flue linings are slightly different because of the lack of standardization.



ROUND. ELLIPTICAL. SQUARE. OBLONG.

FIGURE 1.—Round flues offer the least resistance to the passage of gases, but most residence flues are made either square or oblong for structural reasons

TABLE 1.—*Sizes of chimney flue and height of chimney recommended*

Diameter of smoke pipe or round chimney flue	Size of chimney flue	Height of chimney flue above grate	Diameter of smoke pipe or round chimney flue	Size of chimney flue	Height of chimney flue above grate
<i>Inches</i>	<i>Inches</i>	<i>Feet</i>	<i>Inches</i>	<i>Inches</i>	<i>Feet</i>
8	8 by 12	35	15	16 by 16	45
9	8 by 12	35	16	16 by 18	45
10	12 by 12	35	17	16 by 20	50
11	12 by 12	40	18	16 by 20	55
12	12 by 12	40	19	20 by 20	55
13	12 by 16	40	20	20 by 24	60
14	12 by 16	45			

The flue for a furnace or other large heating unit should be not less than 8 by 12 inches and not less than 12 by 12 inches if the height, above the grate level, is more than 35 feet. If the chimney is de-

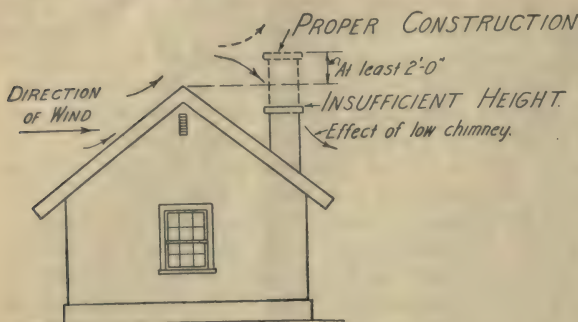


FIGURE 2.—Top of chimney should be at least 2 feet above the top of ridge in order that the wind currents may not be deflected down the chimney

signed for a small unit, such as a laundry stove or kitchen range, an 8 by 8 inch flue may serve. The proper size of flue depends upon the size of the heater or furnace for which it is to be used. All manufacturers' catalogues contain the size of the smoke pipe for each particular heater, and from Table 1 minimum dimensions of corresponding round and rectangular flues may be obtained. If the catalogue gives stack dimensions the specified size should be used. Fire-clay flue linings should have a transverse net inside area approximately equal to that of the smoke pipe.

HEIGHT OF CHIMNEY

In Table 1 the minimum height of the chimney above the grate is given as 35 feet. Higher chimneys are considered more satisfactory, and authorities claim that any flue under 40 feet in height will produce an erratic draft, good on some days but poor on others. The force or direction of the wind may be the cause, or the amount of moisture in the air, or the quality of the fuel may be responsible. The higher the chimney the less will be the possibility of counter air currents and the stronger and more constant the draft. Soft coal and the sizes of hard coal known as pea and buckwheat are apt to cake and fill up the air spaces through the bed of the fire, making an intense draft necessary to provide the fuel with sufficient air.

The top of the chimney should extend at least 3 feet above flat roofs and 2 feet above the ridge of peak roofs (figs. 2 and 3), and it should not be on the side of the house adjacent to a large tree or a

FIGURE 3.—A photograph of a house with a chimney. The chimney is on the ridge. The house has a gabled roof and a window is visible.



FIGURE 3.—Extensions to the chimney required in order that it might draw properly

structure higher than itself (fig. 4), for these may cause eddies and force air down the chimney. A poor draft will most likely result when the wind is blowing in the direction indicated.

FLUE LININGS

Although chimneys are built without lining to save expense, those properly constructed with fire-clay flue linings are undoubtedly more efficient. Linings prevent disintegration of mortar and bricks through the action of flue gases. This disintegration and that occurring from changes in temperature result frequently in open cracks in the flue (fig. 5, B), which reduce or check the draft. If loose brick and mortar should fall within they may lodge so as to cause partial or almost complete stoppage. (Fig. 5, D.) The danger of this latter condition is greater if the flue be built with offsets or bends. Any change in direction should be made as gradual as possible and with an angle not greater than 30° with the perpendicular.

The most important requirement for a flue lining is that it withstand high temperatures and not be subject to disintegration by ordinary flue gases. It should be made of fire clay not less than three-fourths of an inch thick. It should be set in cement mortar with the joints struck smooth on the inside. Each length of flue lining should be placed in position, and the brick should then be laid around it; if the lining is slipped down after several courses of brick have been laid, the joints can not properly be filled with mortar, and leakage is almost sure to result.

Well-burned clay flue linings are generally satisfactory for dwelling-house chimneys used for stoves, ranges, fireplaces, and furnaces. In regions where the fuel is natural gas, hot flue gases are said to have caused linings to disintegrate and crumble off. In such a case it may be necessary to use a fire clay that has stood the test or line the chimney with fire brick.

Linings are manufactured in round, square, and oblong shapes, but not in elliptical. The oblong and square shapes are better adapted to brick construction than the round. They permit of simpler and less expensive masonry work. On the other hand, the round shape produces better draft and is easier to clean.

LOCATION AND WALL THICKNESS

The best location for the chimney is near the center of the building, for when so located its four walls are kept warm; cold winds can not chill it and cause it to draw poorly. However, it is not always pos-



FIGURE 4.—Large trees located near chimney tops may deflect wind currents down the chimney. This may be avoided by placing the chimney on the opposite side of the building

sible to plan the arrangement of rooms so that the chimney may be thus located. The outside wall of a chimney should be at least 8 inches thick in order to reduce heat loss and the chance of air leakage into the flue.

The walls of all chimneys should be built of brick, stone, reinforced concrete, or hollow units of clay or concrete. The minimum thick-

ness of chimney walls not more than 30 feet high should be 4 inches for brick, 4 inches for reinforced concrete, 8 inches for hollow building units, and 12 inches for stone. All such chimneys should be lined. Linings may be omitted in chimneys having walls of reinforced concrete not less than 6 inches thick and unreinforced concrete or brick not less than 8 inches thick, although lining is desirable in the case of brick construction.

If there is more than one flue in a chimney, the flues should be separated from each other by a division wall of brick or concrete at least 4 inches thick (fig. 6), bonded into the side walls, and the joints of the flue linings should be staggered or offset at least 7 inches. This construction insures stability, reduces the chance for air leakage between flues, and prevents the possibility of a fire in one flue involving an adjacent flue.

Although not considered the best practice, it is sometimes necessary to place two linings in the same flue space, in which case the joints of such adjoining flue linings should be staggered at least 7 inches and particular care

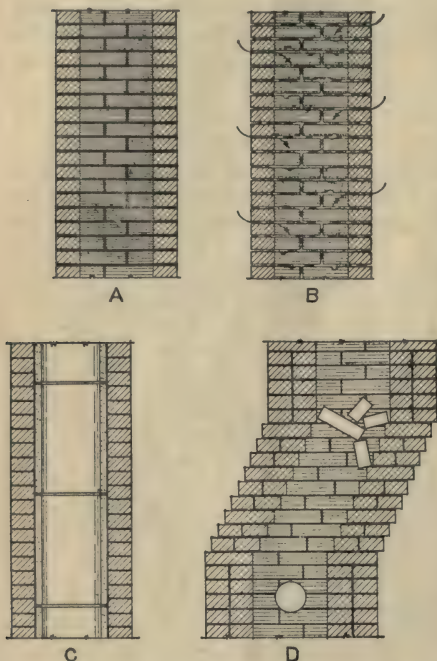


FIGURE 5.—A, an unlined chimney before use. B, same chimney, after being in service. Frequently the heat and weather cause the mortar to disintegrate so that air leaks in through the joints, causing a reduction in the draft. C, same chimney as A, showing fire-clay flue lining in place. D, an unlined chimney with offset. Loose brick and mortar may fall and become lodged at the offset during construction or loosening of the joints and disintegration may cause bricks from an uncapped chimney to check the draft completely

taken to see that all joints are well filled with mortar. Each flue intended for a heating furnace or boiler connection or for a fireplace should be separated from other flues.

OPENINGS INTO THE CHIMNEY

It is not unusual to find a second opening into a flue intended for the smoke pipe of the main heating apparatus. This is a frequent cause of unsatisfactory operation. No range, stove, fireplace, or ventilating register should be connected with the chimney flue built for the heating apparatus. If it is desired to use an abandoned fireplace chimney for a range or stove, the fireplace flue should be closed

tight about a foot below the place where the smoke pipe enters. There should be but one connection with a flue, if for no other reason than to decrease the fire hazard. Fires frequently occur from sparks that pass into the flue through one opening and out through another.

A soot pocket provided with a door for cleaning it out is sometimes very convenient. The door should be placed just below the smoke-pipe opening, and care must be taken to see that it fits snugly and is always closed so tight that no air can get in. If clean outs are used there should be one for each flue. If two or more flues are connected with a single clean out, air may be drawn from one to another, the draft in all of them being affected.

The value of the clean-out door is questionable since the metal smoke pipe connecting the heating unit and the chimney should be taken down each year for cleaning, at which time any accumulation of soot at the base of the chimney may be removed. Deep pockets permit accumulation of soot that may take fire. Linings of heater or stove flues should start from a point not less than 8 inches below the center line of the smoke-pipe intakes. Any hollow space below this point should be closed with solid masonry to prevent soot accumulation below.

SUPPORTING THE CHIMNEY

All chimneys should be built from the ground up. None of the weight should be carried by any part of the building except the foundation. Proper foundations should be provided at least 12 inches wider all round than the chimney. If the chimney is an exterior one and there is no basement or cellar, its foundation should be started well below the frost line. Otherwise the base of the chimney should be at the same level as the bottom of the foundation of the building.

No chimney should rest upon or be carried by wooden floors, beams, or brackets, nor should it be hung from wooden rafters. Wood construction shrinks, and beams supporting heavy loads always deflect in time. Sagging of the beams injures the walls and ceilings of the house and is apt to crack the chimney and render it dangerous. Chimneys usually extend several feet above the roof, exposing considerable surface to the wind, and unless the support is stable they are likely to sway during a gale with the possibility of the joints at the roof line opening. Openings in a flue at this point are especially dangerous, for sparks from the flue may come into contact with the woodwork of the roof. This swaying may also cause leaks in the roof.

The brickwork around all fireplaces and flues should be laid with cement mortar, as it is more resistant than lime mortar to the action of heat and flue gases. It is well to use cement mortar for the entire chimney construction. All mortar used for chimney construc-

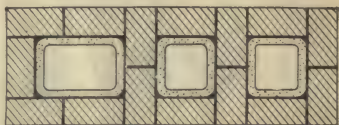
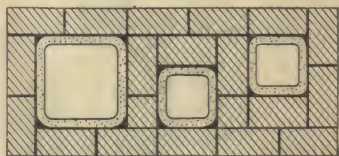


FIGURE 6.—A division wall of at least 4 inches of brick should separate each flue from any others in the same chimney. Either of the arrangements shown will produce a good bond

tion, except for laying fire brick, should be proportioned as follows: To one bag of Portland cement, not less than 94 pounds, add 9 pounds of dry hydrated lime, thoroughly mixing in dry form, and to the mixture add three times its volume of clean sand with sufficient water to produce proper consistency. When dry hydrated lime is not available, one-half cubic foot of completely slaked lime putty may be substituted for the dry hydrate.

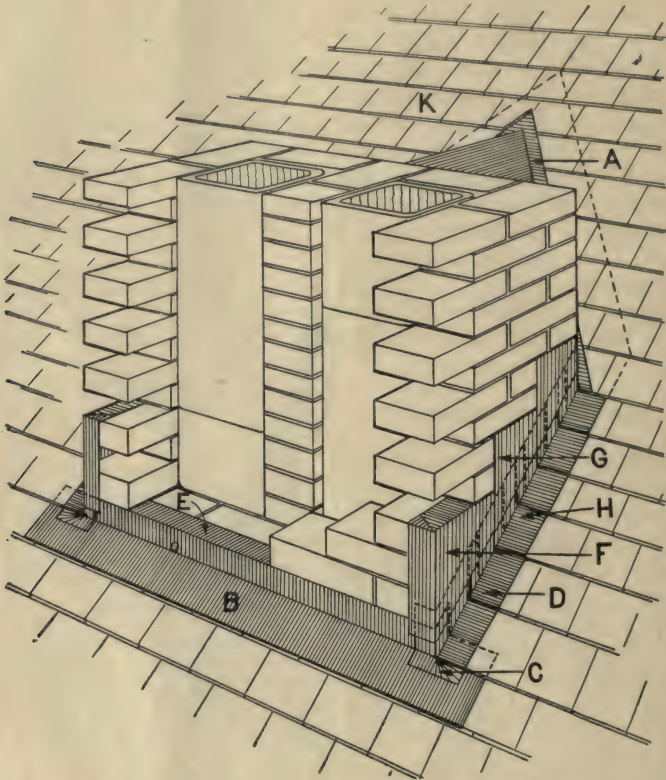


FIGURE 7.—Chimney and roof connection. Sheet metal A should extend under shingles K at least 4 inches. Apron B bent as at E with base flashings C, D, and H and cap flashings F and G, lapping over the base flashings provide watertight construction. When the chimney contains two flues the joints should be separated as shown

CAPPING THE CHIMNEY

Brick chimneys should be capped with stone, concrete, or cast iron. Unless a chimney is capped the top courses of brick may become loosened and therefore dangerous. Plain topped chimneys will last longer and are safer than those of an ornamental character. The opening in the cap piece should be the full size of the flue.

CHIMNEY AND ROOF CONNECTION

Where the chimney passes through the roof the construction should provide space for expansion due to temperature changes, settlement, or slight movement of the chimney during heavy winds. (Fig. 7.)

Copper is the best material for flashings. It is easier to handle than galvanized sheet metal, which is more often used because of its lower cost but which will corrode in time, both from inside and outside exposure. Tin or black iron are cheaper but will rust quickly unless frequently painted. Lead and zinc are expensive and should not be used for chimney flashings, for in case of fire under the roof they will melt and leave an opening to create a draft by which the intensity of the fire will be increased.

CHIMNEY CONNECTIONS

Proper care in setting and looking after smoke pipes connecting with chimneys would greatly lessen the number of fires chargeable to defective construction.

In fitting the smoke pipe no opening should be left around it, and the pipe should not project into the flue lining. (Fig. 8.) The joint should be made air-tight by a closely fitting collar and boiler putty or fireproof cement.

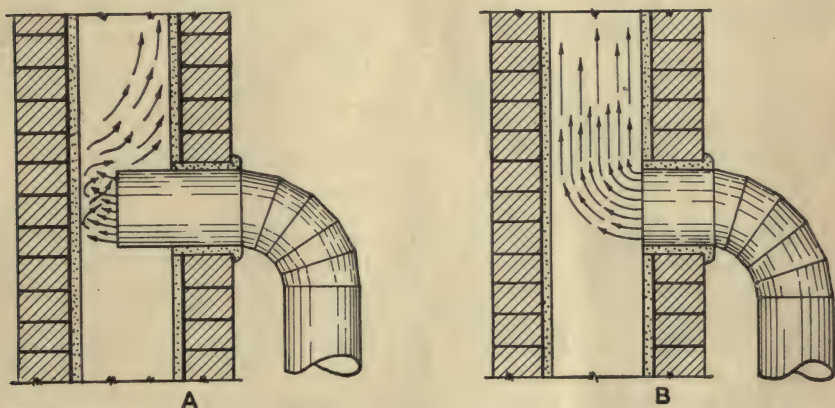


FIGURE 8.—A, wrong connection, producing interference and a poor draft; B, correct construction, producing a good draft by providing a free passage for the gases

Smoke pipes should enter the chimney horizontally, and the connection through the chimney wall to the flue should be made with fire clay or metal thimbles securely and tightly set in the masonry. If the walls are furred, no wood should be within 12 inches of thimbles or any part of the smoke pipe. The space between the thimble and wood furring should be covered with metal lath and plaster.

Flue holes when not in use should be closed with tight-fitting metal covers. If the room is papered, the metal covers may also be papered, provided there is no other smoke connection with the flue, or provided a protective coating of asbestos paper is first applied over the metal. If there is another connection, the metal may become hot enough to scorch the unprotected wall paper or set it afire. No smoke pipe should be permitted within 18 inches of any woodwork unless at least that half of the pipe nearest the woodwork is protected properly by 1 inch or more of fireproof covering. A metal casing 2 inches from the upper half of the pipe is sometimes

employed to protect woodwork directly above it. When a smoke pipe is so protected it should never be less than 9 inches from any woodwork or combustible material. The storage of wooden boxes, barrels, or any combustible material should not be permitted under or near a furnace smoke pipe.

If a smoke pipe must be carried through a wood partition, the woodwork should be properly protected. This can be done by cutting an opening in the partition and inserting a galvanized-iron double-wall ventilating thimble at least 12 inches larger than the smoke pipe (fig. 9), or protection may be afforded by at least 4 inches of brickwork or other incombustible material. Smoke pipes should not pass through floors, closets, or concealed spaces. They should not enter a chimney in a garret. They should be cleaned at least once a year.

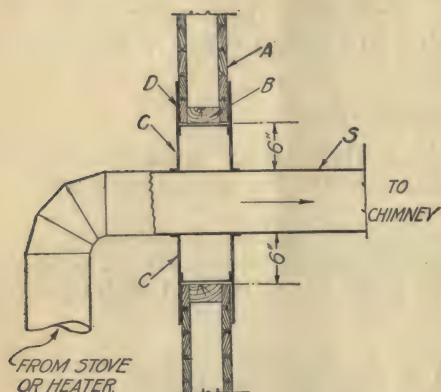


FIGURE 9.—Smoke pipe passing through a partition. A, $\frac{7}{8}$ -inch sides of partition; B, 2 by 4 studs in partition; C, ventilating holes in the double galvanized-iron ventilating thimble D. Thimble should be at least 12 inches larger than pipe S

CHIMNEY INSULATION

All wooden construction adjacent to chimneys should be insulated. A space of 2 inches should be left between the outside face of a chimney and all wooden beams or joists. This space should be filled with some porous, nonmetallic, incombustible material. Loose cinders serve well. Brickwork, mortar, or solid concrete should not be used. The filling should be done before the floor is laid, as it not only forms a fire stop but prevents accumulation of shavings or other combustible material. Baseboards fastened to plaster which is directly in contact with the outside wall of a chimney should be protected by placing a layer of fireproof material at least one-eighth inch thick between the woodwork and the plaster. (Fig. 10.)

Wooden studding, furring, or lathing should not under any circumstances be placed against a chimney. Wooden construction should be set back from the chimney as indicated in Figures 11 and 12; or the plaster may be applied directly to the masonry or to metal lathing laid over the masonry. The former is the better method, as settlement of the chimney will not then crack the plaster. It is recommended that a coat of cement plaster be applied directly upon the masonry of any parts of a chimney that are to be incased by a wooden partition or other combustible construction.

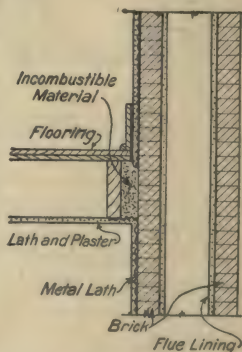


FIGURE 10.—No woodwork should be permitted closer than 2 inches to the outside face of a chimney. Baseboards in front of chimneys should be protected with asbestos board

SMOKE TEST FOR LEAKAGE

Every flue should be subjected to a smoke test before the heater is connected with it. This may be done as follows: Build a paper, straw, wood, or tar-paper fire at the base of the flue, and when the smoke is passing in a dense column tightly block the outlet at the top by laying a wet blanket over it. If leakage exists at any point it will immediately become apparent by the appearance of smoke at the opening. Flues so tested frequently reveal very bad leaks into adjoining flues or directly through the walls or between the linings and the wall. When the smoke test indicates leakage the defect should be remedied before the chimney is accepted for use. Remedying such defects is usually difficult, hence it is wise to watch the construction closely as it progresses. Many brick masons say that all flues leak. This is not true; every flue should be tight.



FIGURE 11.—No wooden studding, furring, or lathing should be placed against the chimney. It should be set back as indicated in this figure and in Figure 12

CLEANING AND REPAIRING THE FLUE

If a smoke test shows no leakage and the flue is straight, a hand mirror held at the proper angle at the base affords a means of examination for obstructions. Usual causes of stoppage are broken tile leaning inward, mortar accumulations, loose bricks, birds' nests, partly burned paper, soot from soft coal, tarry deposits from burning wood, etc. A weighted bag of hay or straw attached to the end of a rope may be passed up and down the flue to clean it if there is not too great an offset in it.

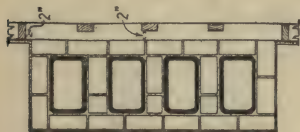


FIGURE 12.—In this construction the chimney masonry is entirely free of all wood-work. Expansion and contraction of the chimney will not crack the plaster if a slip joint is made in the plaster at the intersection of chimney and wall surfaces

FIREPLACES

The use of the fireplace is a very old method of house heating. As ordinarily constructed fireplaces are not efficient and economical. The only warming effect is produced by the heat given off by radiation from the fire and from the back, sides, and hearth of the fireplace. Practically no heating effect is produced by convection; that is, by air currents. The air passes through the fire and up the chimney, carrying with it the heat absorbed from the fire. At the same time outside air of a lower temperature is drawn into the room. The effect of the cold air thus brought into the room is particularly noticeable in parts of a room farthest from the fire.

The open fireplace, however, has its place as an auxiliary to the heating plant and for the hominess that a burning fire imparts to the room. If one is to be provided, the essentials of construction should be understood and followed so that it will not smoke.

ESSENTIALS OF FIREPLACE CONSTRUCTION

In order that satisfactory results may be obtained from an open fireplace, it is essential (1) that the flue have the proper area, (2) that the throat be correctly proportioned and located, (3) that a properly constructed smoke shelf and chamber be provided, (4) that the chimney be carried high enough to avoid interference with the draft, and (5) that the shape of the fireplace be such as to direct a maximum amount of radiated heat into the room.

AREA OF THE FLUE

The sectional area of the flue bears a direct relation to the area of the fireplace opening. The area of lined flues should be a tenth or

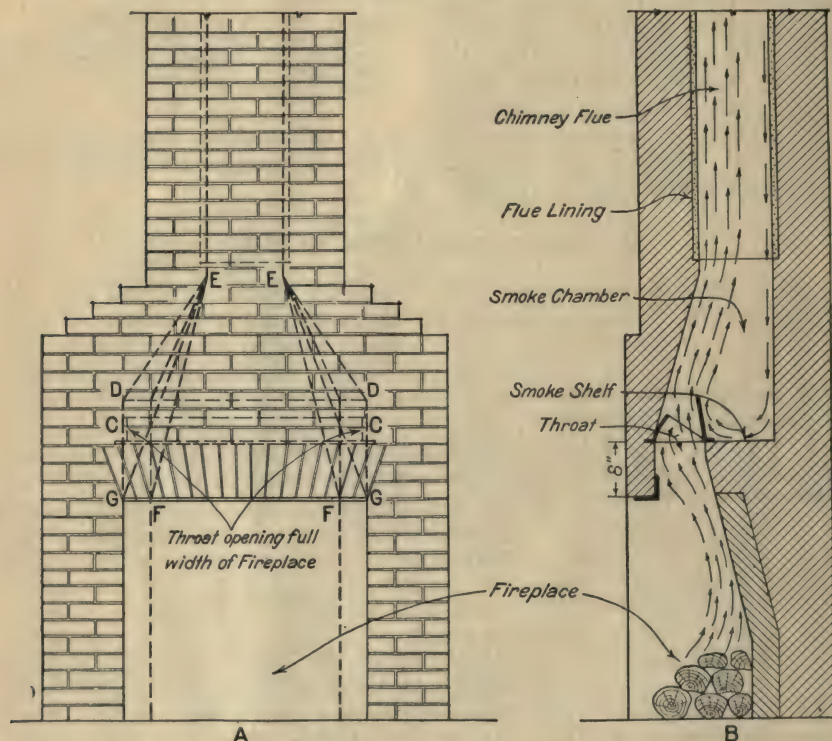


FIGURE 13.—A, top of throat damper is at DD, smoke shelf at CC. Side wall should not be drawn in until the height DD is passed. This assures full area. If the drawing in is done as indicated by lines EF and EG, the width of the throat becomes less than the width of the opening and causes the air currents to pile up in the corners of the throat, resulting frequently in a smoky fireplace. B, correct fireplace construction

more of that of the fireplace opening. If the flues are unlined, the proportion should be increased slightly because of greater friction. Thirteen square inches of area for the chimney flue to every square foot of fireplace opening is a good rule to follow. For the fireplace shown in Figure 13, A, the opening of which has an area of 8.25 square feet, there is required a flue having an area of 107 square inches. If this flue were built of brick and unlined, it would prob-

ably be made 8 inches by 16 inches, or 128 square inches, because brickwork can be laid to better advantage when the dimensions of the flue are multiples of 4 inches. If the flue is lined, the lining should have an inside area approximating 107 square inches. It is seldom possible to obtain lining having the exact required area, but the clear area should never be less than that prescribed above.

Failure to provide a chimney flue of sufficient sectional area is in many instances the cause of an unsatisfactory fireplace. The cross section should be the same throughout the entire length of the chimney. The flue should not be contracted at the chimney top, for that would nullify the larger opening below; if it is necessary to change the direction of a flue the full area should be preserved through all turns and bends, and the change should be made as gradual as possible.

THE THROAT

In Figure 13, B, is shown the throat, the narrow opening between the fireplace and the smoke chamber. Correct throat construction contributes more to efficiency than any other feature except proper flue design. A flue twice as large as is necessary brought straight down to the fireplace without constriction at the throat would result in a poor draft, for the draft does not depend upon the largeness of the flue but upon its proper proportioning to the fireplace and throat. The arrows indicate the upward flowing currents of warm air which are thrown forward at the throat and pass through the smoke chamber into the flue on the inner side. This rapid upward passage of air causes a down current on the opposite side, as indicated by the descending arrows. The down current is not nearly as strong as the up current, but it may be of such force that if there is no throat in the fireplace (fig. 14) to increase the velocity of the upward current by constricting it, the meeting of the two currents will result in smoke being forced out into the room. Thus it frequently happens that a fireplace has an ample flue area and yet smokes badly. The influence of the throat upon the upward and downward air currents is shown in Figure 13, B.

The area of the throat should not be less than that of the flue. Its length should always be equal to the width of the fireplace opening. (Fig. 13, A.) The sides of the fireplace should be vertical until the throat is passed. (DD in fig. 13, A.) Above the throat the sides should be drawn in until the desired flue area is attained. The throat should be set 8 inches above the location of the lintel, as shown in Figure 13, A and B. The wrong way to place the throat damper is shown in Figure 15. The throat should not be more than 4 or 5 inches wide. The lesser width is a safe standard. If a damper is

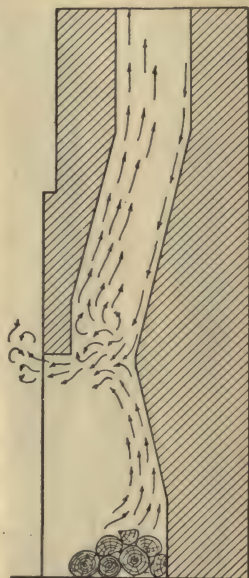


FIGURE 14. — Fireplaces constructed like this without throat will very likely smoke

installed, the width of the brick opening at the throat will depend upon the width of the frame of the damper, the width of the throat proper being regulated by the hinged cover of the damper. If the throat damper is omitted, the opening should be 4 inches, as shown in Figure 16. The smoke shelf should not be bricked up, but should conform to the dotted lines. The depth of the smoke shelf should be the same for a 2-foot as for a 10-foot fireplace opening.

Proper throat construction is so necessary to a successful fireplace that the work should be carefully watched to see that the width is not made more than 4 inches and that the side walls are carried up perpendicularly until the throat is passed, so that the full length of opening is provided. All masons do not appreciate these fine but necessary points. Many prefer their own methods and sometimes will ignore the proper methods. It is therefore advisable to inspect the work several times a day as it progresses and thus avoid poor results. When trouble is experienced in an existing fireplace that has ample flue area, it is usually found that the formation of the throat is the cause.

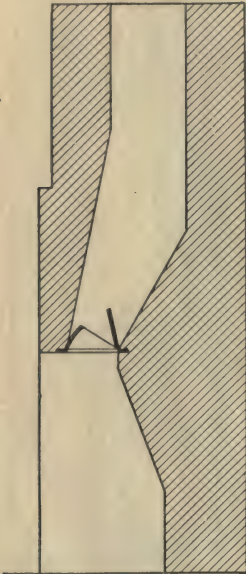


FIGURE 15.—Wrong location for throat damper. The throat is so low that the accumulation of gases at the point constricted weakens the draft with greater likelihood of a smoky fireplace. Note that the smoke shelf is bricked up. This is wrong

SMOKE SHELF AND CHAMBER

A smoke shelf and chamber are absolutely essential. The shelf is formed by setting the brickwork back at the top of the throat to the line of the flue wall. The shelf should be the full length of the throat. The depth of the shelf should be not less than 4 inches. It may vary from this to 12 inches or more, depending upon the depth of the fireplace.

The purpose of the smoke shelf is to change the direction of the down draft so that the hot gases at the throat will strike it approximately at a right angle instead of head on. Therefore the shelf should not be bricked up as in Figures 15 and 16, but should be made as wide as the construction will permit at a height of 8 inches above the top of the fireplace opening.

The smoke chamber is the space extending from the top of the throat up to the bottom of the flue proper and between the side walls,

which may be drawn in after the top of the throat is passed. The area at the bottom of the chamber is quite large, since its width includes that of the throat added to the depth of the smoke shelf. This space is capable of holding accumulated smoke temporarily in case a gust of wind across the top of the chimney momentarily cuts off the draft. Smoke might be forced into the room if there were no reservoir to hold it. The smoke chamber also lessens the force of the down draft by increasing the area through which it passes. If the walls are drawn inward 1 foot for each 18 inches of rise, friction is reduced and interference with the draft lessened.

The walls of the smoke chamber should be smoothly plastered with cement mortar not less than one-half inch thick, for roughness seriously impedes the upward movement of the air currents.

SHAPE OF THE FIREPLACE

The shape of the fireplace proper should be as indicated in Figure 13, A. The back should pitch forward from a point a little less than half way from the hearth to the top of the opening, and the sides should be beveled as indicated. Straight back and sides do not radiate as much heat into the room.

THE THROAT DAMPER

A properly designed throat damper affords a means of regulating the fire. The damper consists of a cast-iron frame with a lid hinged so that the width of the throat opening may be varied from nothing to 6 inches. There are a number of patterns on the market, some of which are designed to support the masonry over the fireplace opening.

A roaring pine fire requires a full throat opening, but slow-burning hardwood logs require but 1 or 2 inches of opening. Regulating the opening according to the kind of fire prevents waste of heat up the chimney. Closing the opening completely in summer keeps flies, mosquitoes, and other insects from entering the house by way of the chimney.

In houses heated by furnaces or other modern systems fireplaces without throat dampers interfere with even heating, particularly in very cold weather. An open fire must be supplied with air, and the larger the fire the greater the quantity required; a fireplace with a width of 5 feet or more may pull air from distant parts of the house. This air that is heated at the expenditure of fuel in the furnace is carried up the chimney and wasted, but with a throat damper open only 1 or 2 inches a slow fire of hardwood can be kept going without smoking the room, thus reducing materially the waste of hot air.

The throat damper should be as wide as the fireplace, so the side walls should not be drawn in until after the throat is passed. Smoke dampers with lid hinged at the back will help the smoke shelf to turn the down draft; if the lid is hinged in the center the downward and upward currents are apt to conflict. The placing of the damper varies with the type, but generally the bottom of the frame is built into the brickwork at the level of the top of the fireplace opening, forming the throat and supporting the masonry above it.

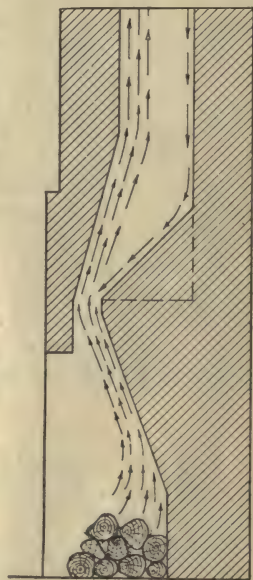


FIGURE 16.—This construction without a throat damper directs the down draft so that it meets the up draft almost at the throat. This is a more serious fault than the construction shown in Figure 15, in which the lid of the damper deflects the down current

SIZE OF FIREPLACE

Pleasing proportions in the fireplace opening are desirable. The width should generally be greater than the height, but as 30 inches is about the minimum height consistent with convenience in tending the fire, a narrow opening may be made square. Three feet and a half is a good maximum for height of opening unless the fireplace is over 6 feet wide. The higher the opening the greater the chance of a smoky fireplace.

A fireplace should be in harmony with the rest of the room in proportions and details. This consideration and the kind of fuel to be used largely determine the size of opening.

Generally speaking the day of large farmhouse fireplaces capable of receiving cordwood is past. The tending of fires usually falls to the housewife, and cordwood is a heavier weight than she should handle, and it can not be stored near at hand. Cordwood cut in two is easily handled; so that a 30-inch width is about the minimum for farmhouses where wood is used for fuel. If coal is burned the opening may be made narrower.

Unless a fireplace with a 6-foot opening is made fully 28 inches deep, in order that large logs may lie well inside, the advantage of the wide opening is lost, for the logs will have to be split. A shallow opening throws out more heat than a deep one of the same width, but can take only sticks of smaller diameter; thus it becomes a question of preference between the greater depth which permits of large logs that burn longer and require less frequent replenishing and the shallower which takes lighter sticks and throws more heat.

In small fireplaces a depth of 12 inches will permit good draft, if the throat is constructed as explained above, but a minimum depth of 18 inches is advised to lessen the danger of brands falling out on the floor. Wire guards should be placed in front of all fireplaces. In general, the wider the opening the greater should be the depth.

THE HEARTH

The hearth should be flush with the floor, for sweepings may then be brushed into the fireplace. An ash dump located in the hearth near the back of the fireplace is convenient for clearing ashes and other refuse from the hearth provided there is space below for an ash pit. The dump consists of a cast-iron metal frame, with pivoted cover, through which the refuse can be brushed into the ash pit below. The ash pit should be of perfectly tight masonry and provided with a tightly fitting clean-out door.

THE JAMB

The jambs of the fireplace should be of sufficient width to give stability to the structure both actually and in appearance. For a fireplace opening 3 feet wide or less, 16 inches is generally sufficient; for wider openings similar proportions should be kept. Greater widths may be required to harmonize with the proportions of the rooms, and the above should be taken as a minimum.

FIREPLACE BACK AND SIDES

The back and sides of the fireplace should be constructed of fire brick only. The bricks should be laid flat with the long sides exposed, for if placed on edge there is danger of their falling out.

SUPPORTING IRONS

In small fireplaces sagging of the arch over the opening seldom occurs, but in fireplaces over 4 feet wide it is not uncommon. It is due to insufficient support of the masonry. Except in massive construction there generally is not sufficient masonry at the sides of the opening to resist the thrust of arch construction; hence it is usual to support the masonry with iron, which, if too light, will sag. Too small an iron will become so hot that its tensile strength is lowered until it bends. A heavy flat bar at least one-half inch thick is sometimes used or a T bar which has greater strength, but less metal; the wider the opening the heavier the bar required.

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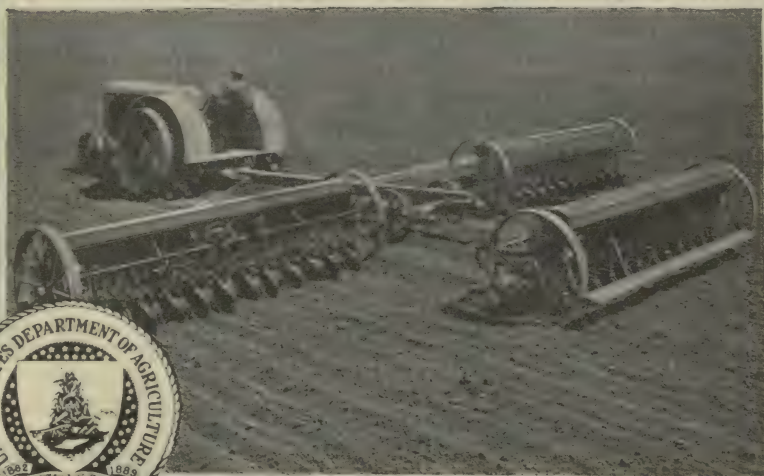
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U. S. DEPARTMENT OF
AGRICULTURE

FARMERS' BULLETIN No. 1650

FLAXSEED
PRODUCTION BY
POWER FARMING METHODS
IN THE NORTHERN
GREAT PLAINS



FLAX FOR SEED production is well adapted to large-scale farming in parts of northeastern Montana and in the Dakotas where wheat is the principal crop, because it extends the seeding and harvesting periods and therefore makes it possible for the farmer to grow a larger acreage of crops with the same equipment.

With a 3-plow tractor, a combine, and the proper equipment of tillage implements a man can operate about 800 acres where approximately half of the land is fallow and half is cropped to wheat each year. By including flax in the cropping system a somewhat larger acreage can be handled and a better distribution of labor obtained.

A firm, well-settled seed bed is essential for flax. The use of a press drill also is desirable.

Where weeds are numerous it is well to delay seeding until the weed seeds have sprouted and the weeds have been killed by cultivation. Comparatively early seeding of flax, however, is desirable.

The use of the combine is the most economical method of harvesting flax. Clean, well-ripened flax can be harvested by straight combining. Weedy or unevenly ripened flax can be harvested better by the use of the windrower or by allowing the crop to stand until the weeds have been killed by frost.

FLAXSEED PRODUCTION BY POWER FARMING METHODS IN THE NORTHERN GREAT PLAINS¹

By A. C. DILLMAN, *Associate Agronomist, Office of Cereal Crops and Diseases, Bureau of Plant Industry*, and E. A. STARCH, *Assistant Agricultural Economist, Montana Agricultural Experiment Station*

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PLACE OF FLAX IN THE FARMING SYSTEM

DURING the early agricultural development of the North-Central States flax was grown extensively as a cash crop on new breaking. It was a pioneer crop. Since 1900, however, flaxseed production appears to have become established as a part of the cropping system in the States of Minnesota, North Dakota, South Dakota, and Montana. (Fig. 1.) It is still grown on new land, where this is available, and on lands where tame-grass sod and pastures are broken up for cultivation or reseeding. In the last few years the tractor and the combine have come into general use on the dry-land farms of the Great Plains. These modern implements have made it possible for the individual farmer to handle more land, and as a result the size of farms has increased. Although the tractor, combine, and larger tillage implements have made it possible to increase the acreage handled, there still is the important problem of getting the work done at the proper time. This is especially true of the operations of seeding and harvesting.

Because of the frequent surplus production of wheat in the United States, many farmers in the northern Great Plains are giving more attention to flax as a cash crop. The substitution of flax for a portion of the spring-wheat acreage in areas where flax is well adapted

¹ The results presented in this bulletin are based partly on experimental work conducted by the department of economics and farm management of the Montana Agricultural Experiment Station on the Fairway farm, Brockton, Mont. It is believed that the information will apply to eastern Montana and to the central and western parts of North Dakota and South Dakota. This bulletin treats only of flax grown for its seed, which is quite different from fiber flax. The straw of seed flax does not yield a fiber suitable for spinning.

has an advantage not only from the standpoint of reducing the acreage of the surplus crop but also from the standpoint of farm organization. Low cost of production depends much upon the greatest possible use of equipment. The optimum season for each operation in the preparation and seeding of spring wheat in the northern Great Plains area is very short; consequently on a farm where only wheat is grown the profitable use of equipment is limited to the acreage that can be covered within the proper time limits.

During the five years from 1925 to 1929, inclusive, the average production of flaxseed in the United States was 20,873,000 bushels annually, whereas the total consumption exceeded 43,000,000 bushels annually. The total consumption includes imports of flaxseed and of linseed oil in terms of seed, and also flaxseed used on farms for seeding. Since there has been a shortage of flaxseed and a surplus

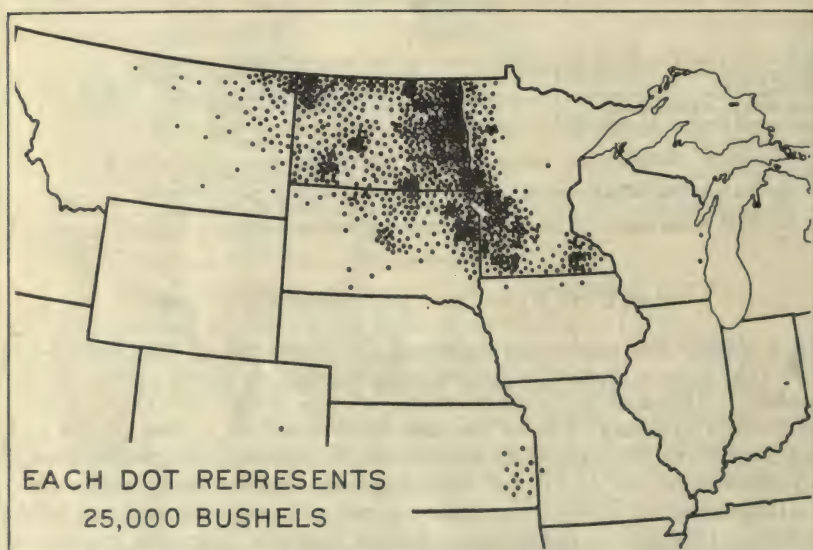


FIGURE 1.—Outline map showing areas of flaxseed production. The principal flaxseed-producing States are North Dakota, Minnesota, South Dakota, and Montana. Large-scale production by power farming methods is practiced most extensively in Montana and the central and western parts of the Dakotas

production of wheat, it is likely that some shift from spring wheat to flax could be made to advantage in the States where both crops are grown.

COMPARATIVE YIELDS OF FLAX AND SPRING WHEAT

In the Dakotas and in Montana the acre yield of flax is roughly half that of spring wheat on the average, although the gross acre value of the two crops is approximately the same. The average acre yields of flax and of spring wheat during the five years from 1924 to 1928 were as follows: North Dakota, 7.2 bushels of flax and 12.2 bushels of wheat; South Dakota, 7.5 bushels of flax and 11.3 bushels of wheat; and Montana, 7.2 bushels of flax and 15.7 bushels of wheat. In 1929 the yields of both crops were markedly lower,

owing to drought, as shown in Table 1. In Minnesota higher acre yields of flax are obtained than in the other States mentioned, and it is generally a more profitable crop than spring wheat.

TABLE 1.—Average yields and acre values of flax and spring wheat for 1929 and for the 5-year period 1924–1928, based on estimated yield and farm price December 1 in the States named

State	Year or period	Yield per acre		Value per acre	
		Flax	Wheat	Flax	Wheat
		Bushels	Bushels	Dollars	Dollars
North Dakota.....	{ 1929	4.7	9.3	13.50	9.60
	{ 1924–1928	7.2	12.2	14.90	13.80
South Dakota.....	{ 1929	5.9	9.5	16.50	9.40
	{ 1924–1928	7.5	11.3	15.40	13.00
Montana.....	{ 1929	3.2	9.0	8.95	8.65
	{ 1924–1928	7.2	15.7	14.20	16.80
Minnesota.....	{ 1929	9.0	13.4	25.80	14.60
	{ 1924–1928	9.7	15.0	20.60	17.65

It will be seen that in the Dakotas the gross acre income from flax has somewhat exceeded that from wheat. In Montana spring wheat has produced a slightly higher gross acre income than flax on the average, but this may be due to the fact that a considerable acreage of spring wheat is grown on fallow land, whereas most of the flax is grown on sod or on spring plowing after wheat. Moreover, flax often is sown too late for best results.

INVESTMENT IN EQUIPMENT

The wheat farmer of the Northwest has more invested in equipment in relation to the number of men employed than has any other farming group. The investment on tractor-operated farms varies from \$4,000 to \$7,000 per worker. To secure the greatest return on investment the equipment must be used to cover as many acres as possible. At the same time the work must be done well and at just the right season. The production of two crops that have different periods for seeding and harvesting makes it possible to extend the season of these farm operations, thus increasing the acreage that can be handled and reducing the acre cost of operation.

On a farm of one to two sections (640 to 1,280 acres) the investment in machinery generally amounts to about \$5 an acre. If a farmer in the northern Great Plains buys a 3-plow tractor and a set of machinery to go with it, he will have about the following implements: One 3-plow tractor, one 3-bottom plow, one 10-foot disk, one 12-foot duck-foot cultivator, one 14-foot drill, and one 10-foot combine. The total cost of this equipment at current prices will be between \$3,700 and \$4,200. On most farms a truck for hauling the grain to market will be an additional part of the equipment.

The investment per acre, based on a total cost of \$4,000 for a minimum full line of equipment, will be as follows:

	Per acre
When 200 acres are farmed.....	\$20.00
When 400 acres are farmed.....	10.00
When 600 acres are farmed.....	6.66
When 800 acres are farmed.....	5.00
When 1,000 acres are farmed.....	4.00

The investment per acre could be reduced to a much greater extent as far as the amount of work a tractor can do in a season is concerned. However, timeliness of operation determines the number of acres that the equipment can cover economically; therefore, on a farm where wheat is grown exclusively, under the fallow or alternate-crop system, the optimum acreage for a 3-plow tractor is about 800 acres, since seeding and harvesting must be done within very limited periods to obtain the best yields and to prevent loss from shattering.

CROP SEQUENCES THAT EXTEND THE USE OF EQUIPMENT

Economic crop production requires that each farm operation shall be performed at the optimum time. This is especially true in the northern Great Plains, where the moisture supply is limited and the growing season is short. One way in which the capacity of machinery equipment can be increased is to grow two or more crops that do not require the same period for seeding and harvesting. Spring wheat and flax fit into this sort of plan because the optimum seeding date for flax is somewhat later than that for wheat. Moreover, flax is not likely to shatter if it is left standing after ripening. Therefore the harvesting of flax may be put off until after the wheat harvest is completed. As the best season for seeding and harvesting flax follows wheat so satisfactorily, it is possible to extend the use of farm equipment over a longer period. In this manner a greater acreage can be handled without additional investment or increased overhead expense, and therefore the acre cost of producing each crop is reduced. From the standpoint of farm management, the substitution of flax for a part of the acreage otherwise used for wheat is desirable, as both crops can be seeded and harvested at more optimum periods than if only one crop is grown. This should result in higher average yields by having the seeding done at a proper time and by reducing the loss from shattering caused when overripe grain is left standing in the field. Moreover, it reduces the peak of labor required during the rush seasons by extending the seeding and harvesting periods two weeks or more.

In most years the optimum period for seeding spring wheat does not exceed 15 to 20 days. If a longer seeding period is required, the later-sown crop will be at considerable disadvantage owing to the hazard of drought and hot weather at filling time. At the northern Montana substation, Havre, Mont., the average acre yield of wheat seeded medium early (May 1-5) has been 7.3 bushels greater than that seeded 20 days later (May 20-25). The average yields from seeding on three dates during the 6-year period from 1924 to 1929, inclusive, were as follows: April 10-15, 22.3 bushels; May 1-5, 23.8 bushels; and May 20-25, 16.5 bushels per acre.² The time for seeding wheat in northern Montana is limited in most seasons to about 20 days; that is, from April 15 to May 5. It is seldom that the soil can be prepared for seeding before the middle of April in that latitude, and the yield of wheat is reduced if seeding is delayed later than the first week in May. Flax, on the other hand, can be sown up to May 25, thus extending the seeding period 15 or 20 days.

² Data furnished by M. A. Bell, assistant agronomist in charge of cereal-crop experiments at the Northern Montana Substation, Havre, Mont.

THE WORK SCHEDULE

On dry-land farms in northeastern Montana summer-fallowing is practiced extensively. On an 800-acre farm a 3-plow tractor will furnish the required power if the work scheduled is well planned. On such a farm about 400 acres are fallow each year. As plowing requires more power than disking, many farmers practice a "plowless fallow," in which the soil is cultivated with a 1-way disk or a duck-foot cultivator instead of being plowed. Usually a part of the land is plowed and a part is prepared by the plowless-fallow method. The seasonal work schedule on a tractor-mechanized farm is about as follows:

Seeding period:	Days
Cultivation before seeding, 400 acres at 40 acres a day-----	10
Seeding, 400 acres at 50 acres a day-----	8
Tractor operation in seeding period-----	18
Summer-fallow operation:	
First cultivation { 200 acres plowed, at 12 acres a day-----	17
200 acres disked, at 40 acres a day-----	5
Second cultivation, 400 acres at 40 acres a day-----	10
Third cultivation, 400 acres at 40 acres a day-----	10
Fourth cultivation, 400 acres at 40 acres a day-----	10
Tractor operation in summer-fallow operations-----	52
Harvest period:	
Harvesting with combine, 400 acres at 27 acres a day-----	15
Total number of days of tractor operation-----	85

The work schedule as outlined will require 18 days for seeding the crop, 52 days for preparing the fallow land, and 15 days for harvesting, or a total of 85 days of tractor operation.

One problem in the use of the tractor on the farm has been the matter of a proper hitch to the various kinds of machinery to be used. In plowing there usually is little difficulty, but in seeding, harrowing, and cultivating it often is difficult to hook together several units so that the load will be distributed and still permit of easy turning at the corners of the field. The subject of tractor hitches is fully discussed in Montana Agricultural Experiment Station Bulletin 229, entitled "Tractor Hitches."

SOIL PREPARATION

There are different methods of preparing the soil for seeding flax in the northern Great Plains, including spring breaking of sod, spring plowing of wheat stubble, summer-fallow, early summer breaking, and seeding on burned wheat stubble.

SPRING PLOWING AND BREAKING

Where spring plowing of wheat stubble or spring breaking of sod is practiced, the land is worked down to a firm seed bed by the use of the disk and harrow and the seeding is done as soon as possible after plowing. The purpose of the cultivation is to kill weeds and to provide a firm, moist seed bed. For spring breaking sometimes only a heavy roller is used, followed by the drill.

SUMMER-FALLOW

The summer-fallow system, in which a crop is grown every other year, is practiced to some extent in eastern Montana. A more common method is to grow two crops after fallow, that is, fallow every third year. In this case spring wheat is sown after fallow and either wheat or flax is grown the third year. The second crop after fallow often is spoken of as "second-year fallow." Where summer-fallowing is practiced the land should be plowed as early as possible after seeding is completed. Early plowing or disking is very important in order to destroy weeds and conserve the soil moisture supplied by early summer rains. Usually three or four cultivations with duck-foot cultivator, rod weeder, or spring-tooth harrow are required during the summer in order to keep the land free from



FIGURE 2.—Cultivating summer-fallow with spring-tooth harrow in eastern Montana. This implement kills small weeds and leaves the soil in good condition to take up water readily and prevent run-off from heavy rains

weeds. (Fig. 2.) The duck-foot cultivator is valuable because it ridges the soil and prevents it from blowing. The rotating-rod weeder is very effective in destroying weeds, especially Russian thistles that have made some growth.

SUMMER BREAKING

When sod land is broken in summer it usually can be put in good condition for seeding the following spring. In Montana this is commonly known as "laid-over breaking." In favorable seasons the sod is disked once or twice in the summer to destroy weeds. In dry seasons it may be necessary to omit cultivation until spring, when the sod is disked well, usually by going over it twice with a tandem disk and harrowing before seeding. Summer breaking often produces as good crops as does summer-fallow,

especially if the sod is broken early and kept free from weeds. Figure 3 shows tractor plows breaking sod land in summer in eastern Montana.

FLAX ON BURNED STUBBLE

When a 3-year rotation of summer-fallow, wheat, and flax is practiced, the wheat stubble is burned early in the spring and the land disked at once in preparation for flax. Seeding can be done at once after the stubble is burned and the land disked, or it may be delayed for several days so as to give the land two cultivations. If the stubble is burned early the land may be given two cultivations before seeding, once immediately after burning and again about 10 days later, just before seeding. The second disking kills weeds that may have sprouted after the first cultivation. The burning of



FIGURE 3.—Breaking native sod in early summer in eastern Montana. Summer or “laid-over” breaking is kept free from weeds by disking once or twice in late summer, which puts the sod in shape for seeding the following spring. In some cases it is left rough until spring, when it is disked once or twice and harrowed before seeding

stubble followed by disking is a very economical method of soil preparation for flax. Moreover, it is very effective in the control of weeds, especially the Russian thistle. Where the stubble is tall it usually can be burned readily by firing along the windward edge of the field, but where it is thin it may be necessary to use a stubble burner, as shown in Figure 4. Under some conditions it is practically impossible to burn thin stubble completely. In such cases the land may be plowed or disked in preparation for a spring-sown crop, or it may be kept fallow in preparation for a crop the following season.

Because of its possible bad effect on the soil, the writers do not presume to recommend stubble burning as a permanent practice. Although little experimental evidence is available, the experience in some localities indicates that where stubble burning is practiced the soil is more liable to blow than if the stubble is plowed under

and incorporated with the soil. In clay soils the addition of vegetable matter has a beneficial effect, as it tends to prevent puddling, and in sandy soils the stubble helps to prevent blowing by its slight binding effect. On the other hand, the plowing under of a heavy covering of stubble or weeds frequently has an injurious effect on the following crop, especially in dry seasons. Under some conditions stubble burning appears to be justified because of its control of weeds, resulting in better yields of flax, and because of its economy in seed-bed preparation. In years of heavy snowfall the tall stubble holds the snow, which adds to the soil-moisture supply. This may explain why spring-plowed stubble and burned stubble frequently show better results than fall plowing in the northern Great Plains. For further information the reader is referred to Montana Extension Circular 99, entitled "Stubble Burning."



FIGURE 4.—A stubble burner in operation. On thin stubble narrow strips are burned, beginning on the leeward side of the field, so as to insure having a "clean burn."

On the Fairway Farm at Brockton, Mont., where experiments in farm organization and utilization of equipment are being carried on, flax has been grown on a large scale for several years. The crops have been grown under ordinary field conditions such as prevail on most well-tilled farms of Montana. It is of interest to compare the return from flax and spring wheat in 1928, which was a very favorable crop season in that locality, and in 1929, which was an extremely dry year. (Table 2.)

TABLE 2.—Yields and gross acre values of wheat and flax grown on clean fallow and on burned wheat stubble the second year after fallow, at Fairway Farm, Brockton, Mont., 1928 and 1929

Crop sequence	Yield per acre		Gross acre value	
	1928	1929	1928	1929
	<i>Bushels</i>	<i>Bushels</i>	<i>Dollars</i>	<i>Dollars</i>
Flax on fallow.....	20	4	38.00	11.00
Flax on burned stubble.....	15	4	28.40	11.00
Wheat on fallow.....	42	14	37.80	13.30
Wheat on burned stubble.....	29	9	26.10	8.55

On summer-fallow the gross return per acre from flax was approximately the same as from wheat in 1928 but somewhat less than from wheat in 1929. On burned stubble the gross return from flax was \$2.30 greater than from wheat in 1928 and \$2.45 greater in 1929. In 1928, a favorable season, the yield of flax on the fallow was 20 bushels an acre, as compared with 15 bushels on burned stubble. In 1929, a dry season, the same yields, 4 bushels per acre, were obtained on both summer-fallow and burned stubble. The results obtained in these two seasons of extremely different weather conditions are of interest as indicating the approximate limits of crop yields that may be expected under the best farming practices in that locality.



FIGURE 5.—Disking and seeding burned stubble land to flax in one operation. The use of a press drill is very desirable for seeding flax, as it firms the soil, insuring better germination of the seed

SEED-BED PREPARATION AND SEEDING

A firm seed bed is very essential for flax. The aim of cultivation, therefore, should be to kill all weed growth and still leave the soil in a settled and, if possible, a moist condition so as to insure quick germination. In dry-land farming this condition usually can be provided by disking, seeding, and firming the soil in one operation. Figure 5 shows a tractor drawing a disk and a press drill in seeding flax on burned stubble land. It is important that all weeds should be destroyed by cultivation just before seeding so that the flax will have at least an even start with any freshly sprouting weeds. A loose seed bed should be avoided, as the soil dries out rapidly when in that condition.

The use of a press drill is desirable for seeding flax, especially in the dry-farming area. As this type of drill firms the soil around

the small seeds, it appears to favor quick and uniform germination of the seed. It is desirable to seed flax rather shallow, usually not to exceed 1 inch deep. If the seed is sown too deeply in loose soil the seedling plants can not reach the surface. For this reason a firm, smooth seed bed is desirable. (Fig. 6.)

RATE OF SEEDING

Under conditions of limited rainfall flax is sown at the rate of about 20 pounds to the acre. On breaking, it is a common practice to seed 1 bushel of flax on 3 acres, or at the rate of 19 pounds to the acre. In experiments conducted on old ground at the United States Northern Great Plains Field Station, Mandan, N. Dak., where the annual rainfall averages about 16 inches, the yield of flax sown at

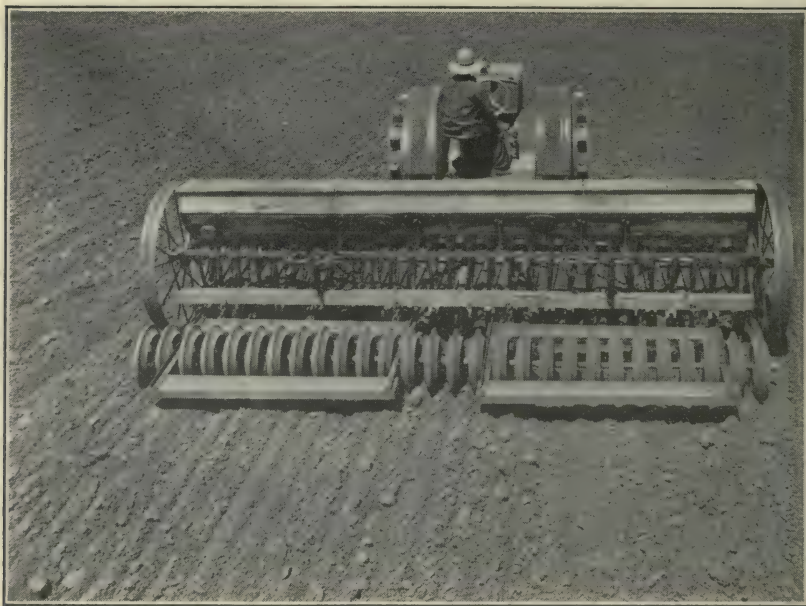


FIGURE 6.—A type of packer with wedge-shaped wheels designed to firm the soil and still leave the surface somewhat ridged to prevent soil blowing. The packer can be attached to any type of drill

the rate of 24 pounds to the acre has been about 20 per cent greater than where the seeding rate was 16 pounds to the acre. A seeding rate of 32 pounds to the acre has produced nearly the same yield as the 24-pound rate. On old land where weeds are prevalent a somewhat heavier rate of seeding is desirable than is required on clean land or breaking. Where the rainfall is greater, as in Minnesota and the eastern half of the Dakotas, a heavier rate of seeding, up to 42 pounds to the acre, is recommended.

DATE OF SEEDING

Flax requires from 90 to 120 days to complete its development from time of seeding to maturity, the time required depending on the character of the growing season, the date of seeding, and the

variety grown. Although good yields sometimes are obtained from flax sown as late as June 15, higher yields on the average are obtained from early seeding. In practice, flax should be sown as early as possible after the seeding of spring wheat is completed. At the United States Northern Great Plains Field Station the best results have been obtained from seeding from May 1 to 20. Lower yields have been obtained from seeding on June 1, and markedly lower yields resulted when seeding was delayed as late as June 10 to 15. On the other hand, there was no advantage from seeding as early as April 15, as occasionally this early sown crop is damaged by freezing in that locality. At the Judith Basin substation, Moccasin, Mont., about the same results have been obtained as at Mandan. As an average of four years' results, flax seeded the first week in May yielded 19.3 bushels, that seeded the third week in May, 15.9 bushels, and that seeded the first week in June, 10.8 bushels per acre. There was a loss, therefore, of 5.1 bushels per acre, or 32 per cent, by delaying seeding from the third week in May to the first week in June. Good yields of flax can be expected if timely rains occur during the filling stage, that is, for 20 to 30 days after blossoming. During that time the oil is formed in the developing seed, and the growth of the seed is practically completed. The process of ripening is largely a matter of dehydration or loss of moisture from the seeds.

VARIETIES OF FLAX

Three wilt-resistant varieties of flax have been introduced in recent years by the North Dakota Agricultural Experiment Station and are now grown very generally in the flax-producing States. These varieties are Linota, Buda, and Bison. The Bison variety is remarkably wilt resistant. It has blue flowers and medium-large brown seeds which usually yield a higher percentage of linseed oil than the small-seeded flaxes. On land where flax has been grown previously one of these varieties is recommended as insurance against loss from flax wilt.

On new lands, where wilt has not been introduced, the so-called Russian flax will give good results. Newland and Reserve are two varieties of this type. N. D. R. No. 52, which is somewhat wilt resistant, is grown widely in western North Dakota and eastern Montana. The large-seeded Argentine flax is grown to a limited extent in some localities. It is more or less resistant to flax wilt, and the plants are practically immune from flax rust. The commercial Argentine seed is not well adapted, however, to the flax-producing area of the United States. The plants generally are short and are not uniform in ripening, especially in wet seasons or if seeded late. In favorable seasons Argentine flax does well, but on the average it has not yielded so well as have the improved varieties (Linota, Buda, and Bison) already mentioned. A selection of Argentine flax named Rio, which was developed by the North Dakota station, is superior to the commercial Argentine flax.

HARVESTING FLAX

Different implements are used for harvesting flax, each designed to produce some economy in the labor required for handling the

crop. In the eastern part of the flax-producing area flax generally is harvested with the binder, and the bundles are placed in shocks to dry before threshing. (Fig. 7.) In the western and drier part



FIGURE 7.—Flax being harvested with the binder and placed in long narrow shocks to dry before threshing

of the flax-producing area the reaper and the header formerly were used extensively. The header is still used in some localities. In harvesting with the header the flax either is dropped in small



FIGURE 8.—Flax being harvested with the header and stacked in narrow ricks to dry before threshing. This method is more economical of labor than harvesting with the binder, but much less economical than with the combine. The header requires a crew of five men and eight horses, as compared with two men and a tractor required to harvest and thresh with the combine

bunches on the ground, where it remains until it is dry enough to thresh directly from the field, or it is stacked from header boxes, as wheat is stacked. (Fig. 8.) In Montana the "header barge"

also is used to some extent. By this method flax that is not fully ripe or that is somewhat weedy is placed in small narrow stacks where it will dry out readily in favorable weather. By use of the header barge flax is harvested with a minimum of labor, the cost of harvesting being about 40 per cent less than when it is stacked from the header box by the usual method. (Fig. 9.) During the last two or three years the modern combine has displaced other methods of harvesting to a large extent.

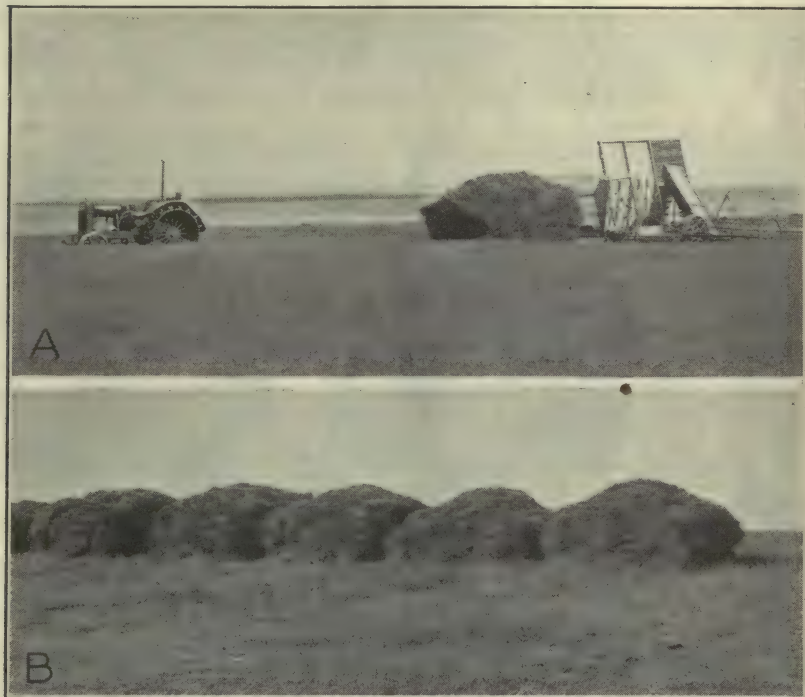


FIGURE 9.—(A) Removing a small stack of flax from the "header barge"; (B) a setting of such stacks. The barge consists of a rigid box with smooth bottom and sides built on a heavy low-wheeled truck. The rear end is constructed of strong poles and is hinged so that it may be lowered when the stack is pulled out

COMBINE HARVESTING

The cost of harvesting flax has been materially reduced by the use of the combine. Three more or less distinct methods of combine harvesting—direct combining, delayed harvesting, and windrowing—can be used, depending upon the condition of the crop.

When the crop is free from weeds and has ripened uniformly, direct combining is the cheapest method and is entirely satisfactory under favorable conditions. The cost of harvesting flax with a combine in eastern Montana has been \$2.16 an acre—the average of 60 available records.

If flax is weedy it often is allowed to stand until frost has killed the weeds. Weeds dry up rapidly after being frozen, and the flax crop can be harvested in a few days after frost. Ordinarily flax will stand for a considerable time after ripening without loss from shat-

tering. In very dry hot weather, however, it may shatter somewhat and, therefore, delayed harvesting can be recommended only when late flax does not have to stand too long before frost.

If the flax crop is weedy the use of the windrower is recommended. In dry weather the windrowed flax will be in condition to thresh in three or four days after harvesting. (Fig. 10.) Occasionally there is some difficulty in picking up windrowed flax if it has settled down in Russian thistles. To avoid such difficulties it is desirable to thresh the crop as soon as it is dry. Occasionally the flax crop does not ripen readily because of damp cool weather, and in such seasons the use of the windrower is necessary.

The operation of the windrower costs about 50 cents an acre. In spite of the extra cost, farmers having a considerable acreage to



FIGURE 10.—Threshing flax from the windrow. In heavy stubble the windrow swath is held off the ground, where it dries out rapidly in clear weather

harvest will find it desirable to have some sort of windrower to meet the conditions just described.

Grasshoppers and crickets sometimes cause material losses in flax fields by cutting off the bolls and eating the seeds. Where these insects are present in considerable numbers flax should be harvested and threshed as soon as possible after ripening. The use of the windrower, followed by the combine as soon as the flax is dry, is perhaps the most rapid method of saving the crop from loss. Flax should be threshed as soon as it is sufficiently dry to avoid loss from crickets which are very destructive to flax in the windrow or shock.

ADJUSTMENT OF THE COMBINE

Most makes of combines will thresh flax without any extra attachments, an adjustment of the sieves and air blast usually being all

that is necessary. If the flax is dry when threshed, little trouble will be experienced. In some combines it is desirable to cover a part of the beaters and any shafts where possible in order to prevent the flax stems from winding about these parts.

If flax stems collect on the pegs of the beater, the pegs can be covered by attaching a light 2 by 4 inch scantling in which holes have been bored to fit the pegs. If flax winds on the revolving shafts, they can be covered with gas pipe cut the right length to cover the entire shaft. The gas pipe should fit closely against the shaft bearings for support so as to allow the shaft to revolve freely and without friction within the pipe. These devices can be used on some makes of combines, but not on all kinds. Each combine operator should get instructions from the manufacturer of his machine in regard to proper adjustments for harvesting flax. It is important that flax should be thoroughly ripe and dry when harvested with the combine; threshing when the straw is damp should be avoided if possible. If, however, flax is somewhat tough the cylinder and other moving parts should be run well up to rated speed. If flax is uncommonly dry some seeds may be broken in threshing. This usually can be avoided by lowering the concaves somewhat, or by slowing down the speed of the cylinder. Cylinder teeth out of line also may be the cause of broken grain. Bent cylinder teeth can be straightened and any that are badly worn should be replaced.

MOISTURE CONTENT OF FLAXSEED

In most years the bulk of the flaxseed received at Minneapolis and Duluth, the principal flaxseed markets, contains from 7 to 10 per cent of moisture. In a wet harvest season, such as prevailed in the eastern half of the flax-growing area during the fall of 1926, flax may contain from 9 to 12 per cent of moisture. On the other hand, when ripe flax is harvested and threshed in very dry hot weather the seed may contain as little as 5 to 7 per cent of moisture. It is considered that flax, when free from dockage, is safe for storage if the moisture does not exceed 11 per cent. The Minnesota grades allow not to exceed 11 per cent of moisture in No. 1 and No. 2 flaxseed.

Ripe flax standing in the field is very hygroscopic; that is, it takes up moisture readily in a humid atmosphere and from dew or rain. It is well known that flax is difficult to thresh when damp. When flax is dry enough to thresh readily, the bolls are semidehiscent; that is, they open at the apex and crack slightly along the margins of the five segments of the boll, but close tightly again when wet by dew or rain. Figure 11 shows a boll of common flax in the dry condition (A) and as closed (B) when wet by dew. This character of dehiscence can be used as an indication of the proper condition of flax for harvesting, particularly with the combine. Flax bolls rarely dehisce so far as to allow the seeds to fall out, although this occurs

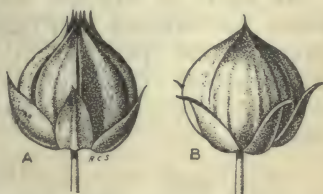


FIGURE 11.—(A) Boll of common flax in which the bolls are semidehiscent when ripe and dry; (B) the same boll when wet by dew or rain. (Twice natural size.) The bolls of some varieties, as the Argentine type of flax, ordinarily remain tightly closed even when fully ripe

sometimes in very dry weather, especially if the seeds are shrunken by drought. Observations made in 1928 and 1929 indicate that dehiscence occurs when the seeds contain from 7 to 10 per cent of moisture. In flax dry enough to thresh readily with the combine the bolls are partly open (semidehiscent). This was the condition of flax in numerous fields observed by the writers in 1928 and 1929 where combines were working efficiently. When the flax is tough, as in the morning after dew or after a trace of rain, the bolls are closed. This discussion does not apply to the Argentine type of flax, in which the bolls ordinarily remain tightly closed even when fully ripe.

STORAGE AND MARKETING

As flax threshes much more slowly than wheat, the crop can be hauled to market directly from the combine in the trucks used during the wheat harvest. If flax is hauled directly to market, loss from leakage and from possible wetting in storage is avoided.

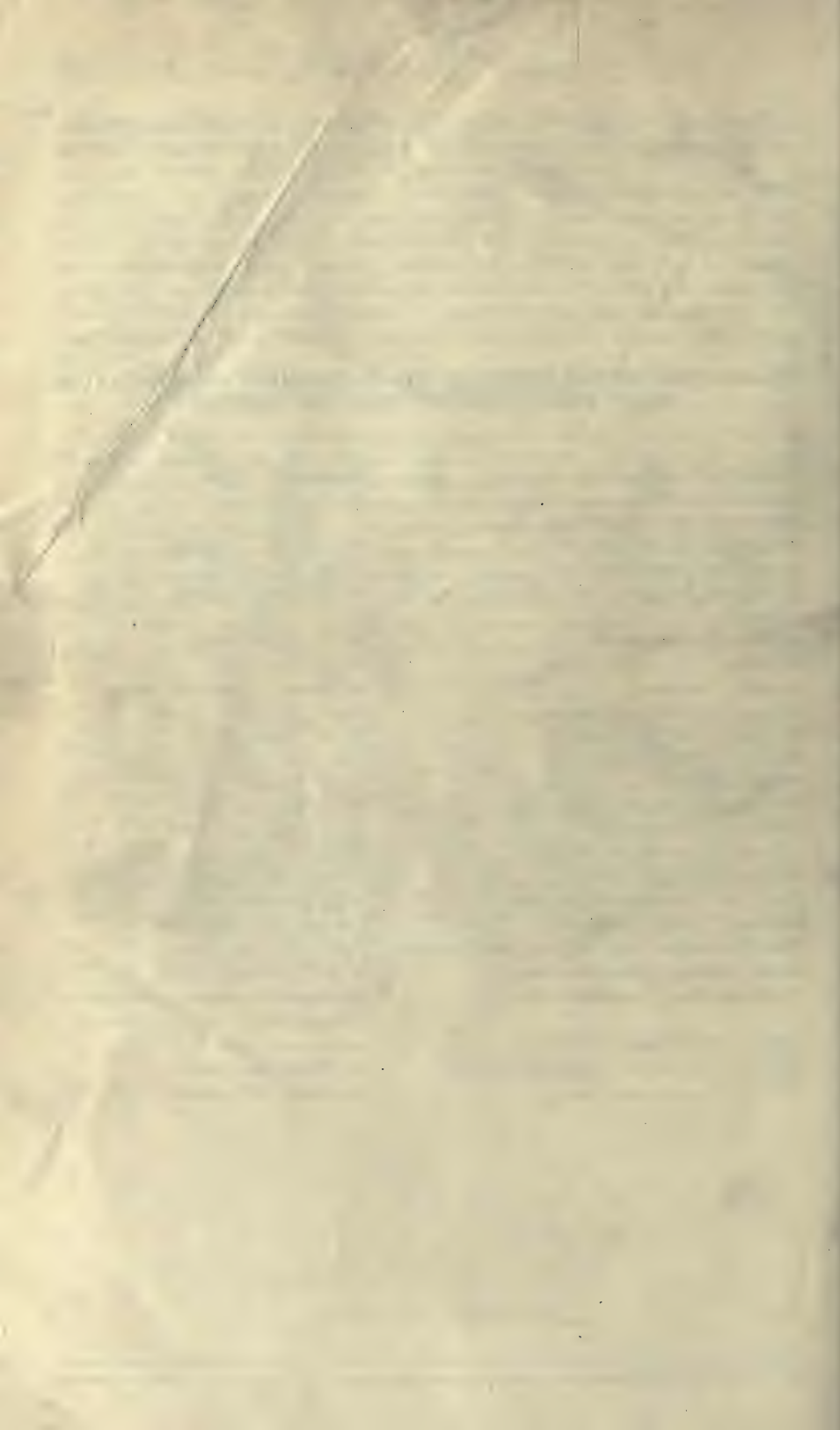
As seeds of flax are very small and slippery, they require tight boxes for hauling and tight bins for storage. Wheat frequently is stored in the open without protection from rain, but this will not do for flaxseed. Seeds of flax have a gelatinlike seed coat which absorbs moisture rapidly, and if wet the seeds cake together in a firm mass.

PRODUCTION COSTS

In studies made at the Fairway Farm, Brockton, Mont., it has been found that less than two hours of man labor per acre are required to produce a crop if the land is fallowed one season and a crop is grown the second year. The operation costs, not including land rental, have averaged approximately \$7.50 per acre, including cost of summer-fallow and the production of the following crop. When flax has been grown on burned stubble, the time required for tillage, seeding, and harvesting has been only three-fourths of an hour of man labor to the acre, and the total cost of operation has been about \$2.50 an acre. In these studies tractor power has been used entirely and the crop has been harvested by a combine.

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